USAFA-TR-74-18

PROJECT "EOQ": FEASIBILITY OF PRICE DISCOUNTS IN PROCUREMENT OF NON-REPARABLE SPARES

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SEPTEMBER 1974
FINAL REPORT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DEAN OF THE FACULTY
UNITED STATES AIR FORCE ACADEMY
COLORADO 80840

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FOR THE SUPERINTENDENT

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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAFA-TR-74-18	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Project "EOQ": Feasibility of Price Discounts in Procurement of Non-reparable Spares		5. TYPE OF REPORT & PERIOD COVERED FINAL REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Lt Col L. M. Austin, Director of Research CMD,AFSC; Captains M. S. Anselmi, R. E. Carlburg, H. A. Clark, USAFA (DFEGM)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS United States Air Force Academy Dept. of Economics, Geog., and Management USAFA (DFEGM) Colorado 80840		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Headquarters, Air Force Logistics Command DCS for Procurement and Production Wright-Patterson AFB, Ohio 45433		12. REPORT DATE September 1974 13. NUMBER OF PAGES 115
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 SUPPLEMENTARY NOTES

Prepared in coordination with the USAF Procurement Research Office, USAF Academy, Colorado 80840

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

EOQ (Economic Order Quantity); Price Discounts; Obsolescence; Demand Forecasting; Holding Cost

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

The original objective of Project "EOQ" was an investigation of the feasibility of installing a price discount solicitation capability in AFLC's procurement system for non-reparable spares. However, the study was later broadened to include an analysis of the basic parameters used in economic order quantity computations. A technique was developed and operationally tested to solicite, evaluate and accept price discounts. A new method of computing

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. the obsolescence rate used in economic order quantity computation was developed and tested. Several demand prediction techniques were also evaluated using four years of actual demand history.

PREFACE

Project "EOQ" was initiated by Headquarters AFLC in January 1974 under the auspices of the Air Force Business Research Management Center. The research was performed by four officers and nineteen cadets in conjunction with Management 534, the Air Force Academy's graduate-level course in logistics management. Although the original objective of the project was to investigate the feasibility of soliciting price discounts in the procurement of non-reparable spares under AFLC's EOQ system, the scope was subsequently broadened to include an analysis of holding costs, ordering costs, and demand prediction techniques.

Research Chronology

In December 1973, Brig Gen Charles E. Buckingham and Lt Col John Slinkard (HQ AFLC) visited the USAF Academy for briefings and preliminary discussions. Maj Sanford Kozlen, the project monitor for AFBRMC, also attended. Actual work on the project began during the first week of the spring semester, and--after background discussions were completed--four teams of cadets, each with an assigned officer, pursued their investigations. In this regard, and at our invitation, Mr. Arnett Burrow and Mr. Ray Robertson of the General Accounting Office visited the Academy in February for discussions; the GAO working papers which they supplied from a recent audit of the EOQ system were

valuable data sources.

A subsequent working session with Mr. Paul Ste. Marie (AFLC/MMR), Mr. Bob Stevens (AFLC/ACD), Maj Kozlen, Mrs. Elsie Akisada (an IM from Ogden ALC), and Mr. Phil Jorgenson (a buyer from Ogden ALC) provided the basis for reorganization of the research effort. Cadet teams (and assigned officers) were subsequently realigned at midterm as follows: computer model building (Capt Anselmi); holding cost analysis (Capt Clark); demand prediction analysis (Capt Carlburg); price discount and ordering cost analysis (Lt Col Austin).

A formal briefing, which also served as the final examination for the cadets, was presented to Mr. R. L. Stanley and Mr. Ira Kemp (AFLC/PP), Mr. F. L. Benson and Mr. Ste. Marie (AFLC/MM), Lt Col Slinkard, and Maj Kozlen at the Academy on 22 May 1974.

Conclusions and Recommendations

Based on the results of extensive analysis, the Project "EOQ" team generated recommendations for changes in AFLC's EOQ system in the following areas: solicitation of price discounts, holding cost, demand prediction, and safety levels. Areas for further research were also identified.

Solicitation of Price Discounts

Since price discount solicitation is commonplace in industry, and since a test program conducted at Ogden ALC indicated both the desirability and feasibility of such a procedure, the team recommends installation of a price discount solicitation capa-

bility at all five ALC's on 1 July 1974. In order to avoid difficulties with FY 75/FY 76 fiscal obligation authority, it is suggested that initial solicitations include only those items which would normally be procured two or more times in FY 75. As savings accrue, the program can be extended to a larger population of items. It should be noted that administrative budget restriction (e.g., the quarterly constraints) must be relaxed or eliminated in order that larger, less frequent purchases can be made. In this way, economies which result in many instances from larger production runs can be realized by manufacturers and passed on to the government in the form of price discounts.

Holding Cost

The present AFLC EOQ system uses a holding cost parameter of .24; that is, the costs associated with opportunity loss, storage, and obsolescense are charged at the rate of 24% against the average on-hand value of AFLC's EOQ inventory. The team is in agreement with the opportunity loss rate (.10) and the storage rate (.01), but recommends that the practice of applying a constant obsolescence rate (.13) to all items--regardless of their nature--be replaced by a variable obsolescence rate. Recommended procedures for computing these rates utilize data available in the basic EOQ computer system (D062) and involve generation of a separate obsolescencerate for each weapon system/FSC combination. Although a variance from DODI 4140.39 instructions on obsolescence rate computation might be required, the team feels that

the recommended variable obsolescence rate computation is more in accord with the <u>intent</u> of the Instruction than is the present AFLC approach.

Demand Prediction

The present EOQ system uses an eight quarter moving average to predict demand for every item in the inventory, the only exception being a four quarter "history control" which is permitted at the option of the Item Manager. The team recommends that EOQ items be segregated into three categories for management purposes: low-demand items, erratic-demand items, and predictable-demand items. Since over 40% of all EOQ items are low demand items (one requisition or less in the past year), it is recommended that these items be identified for "management by exception" and exempted from mathematical forecasting procedures. Extensive tests on the remainder of the items indicate that single exponential smoothing (with a "tracking signal" to assist in detecting trend changes) is by far the best demand predictor. Since inaccurate demand forecasting causes serious problems in excess stock (over-prediction of demand) and in low fill-rates (under-prediction of demand), it is recommended that the new demand prediction technique be implemented as soon as possible.

Safety Levels

The concern expressed by senior managers over excessive stock levels can be focused on the policy for determining safety levels. Safety stock is maintained for the purpose of absorbing

unexpectedly high demand, and its effect is noted mainly in the fill-rate. Current AFLC policy is to maintain a safety stock of one month's supply of all items--regardless of their dollar value or utilization rate. The team recommends implementation of a variable safety level approach which would have the effect of decreasing investment in on-hand inventory while simultaneously improving the fill-rate. Furthermore, a management decision to determine the desired trade-off between stock level and fill-rate is an important option inherent in this approach.

Recommendations for Further Research

1. An attempt by the team to forecast demand for high dollar-value aircraft spares by the use of multiple regression techniques produced inconclusive results. It is believed that demand for these critical items should, logically, be associated with aircraft-related parameters such as flying hours, sorties, and size of aircraft inventory. Further investigation in this area in recommended.

2. Although the team found that AFLC is in compliance with the basic approach directed by DODI 4140.39 in computing ordering costs, it possessed neither the industrial engineering expertise nor the resources for a detailed analysis of the component costs involved. Our "gut feeling" that certain computed costs are unrealistic is shared by Lt Col Slinkard, and we recommend further research in this area.

Projected Savings

In an effort to estimate the savings to AFLC which could result from implementation of the previous recommendations, a simulation model of the proposed system was built and tested on a 9,767-item stratified sample of EOQ items. Although care was taken to use conservative estimates and assumptions at every turn, the results--as depicted below--are nevertheless startling.

<u>Unit Price For EOQ Computation:</u>[1] Last Price Paid
<u>Holding Cost Computation:</u> Variable Obsolescence Rates
<u>Demand Prediction:</u> Single Exponential Smoothing For "Erratic" and "Predictable" Categories
<u>Solicitations:</u> Multiple Quantities for Price Discounts

AVERAGE PRICE DISCOUNT	ANNUAL NET SAVINGS REALIZED
3%	$21.5 Million
5%	$39.6 Million
8%	$68.2 Million

Although the monetary savings depicted above are highly significant (representing savings in annual EOQ system expenditures of 5%-15%), other benefits will also accrue upon full implementation of the team's recommendations. First, the increase in the size of the average buy will cause a dramatic reduction in the number of annual procurement actions. Thus, buyers will be

[1] A recent procedure by AFLC used standard price (unit price plus a 15% surcharge) for computing EOQ. It was recommended that this practice be discontinued; the recommendation has been implemented by AFLC/MMR.

able to use their judgment and experience in elevating the quality of negotiation procedures. Second, the combination of better demand prediction and variable safety level will materially reduce excesses (assets above the retention level) and increase fill-rates. Third, "management by exception" of low-demand items will allow Item Managers to concentrate their attention on critical high-volume spares.

Implementation

The nineteen cadets on the research team were commissioned on 5 June 1974; they are now reporting to their first duty assignments. However, three of the officer members of the team (Capts Anselmi, Carlburg, and Clark) are available to assist AFLC in implementing recommended changes throughout the summer. Travel and per diem funds for this purpose have been made available through the USAF Procurement Research Office located at the Academy, and this continuing effort has been approved by the Academy staff as the major summer activity for these three officers.

Two final observations are in order. Although the test at Ogden ALC was highly successful in eliciting price discounts, the "funds situation" prevented Materiel Management personnel from actually realizing the savings offered. Further testing--with no intention of purchasing the larger quantities--will convince bidders that the government is playing games with price discount solicitations, and they will undoubtedly ignore similar attempts

in the future.

Finally, consider the analogy between AFLC's situation and that of the housewife attempting to run her household efficiently. Price discounts for volume purchases are available on almost every commodity in the supermarket, and she does not need a Ph.D. in Business Administration to know that wise planning can save money. However, if the husband insists upon doling out the grocery money daily, the wife--in order to feed her family--must shop frequently and buy in small, expensive lots. Thus, as is the present practice in AFLC, tight administrative control of available funds leads to excessive costs.

Therefore, the research team most urgently recommends a reassessment of present fiscal policy in AFLC, with the object of allowing materiel management and procurement personnel at the ALC's sufficient latitude to realize available savings.

ACKNOWLEDGEMENTS

The nineteen cadets who worked on Project "EOQ" deserve the major share of credit for this accomplishment. Their names (all are now second lieutenants in the Air Force) are listed below.

Michael Baca
Dale D. Burchby
Edward Carter
P. J. Corrigan
V. Coviello
D. Flattery
M. K. Hathaway
Philip D. Inscoe
William H. Jones
Stephen M. Lenzi
Michael W. McCoy
J. E. Moats
E. S. Richardson
Norman K. Risner
David K. Rusk
F. W. Stone, Jr.
Nicholas Thomas
Steven W. Weiss
Marc A. Wooten

The professionalism and the ability demonstrated by these young men were remarkable, and the faculty members of the team are convinced that Project "EOQ" has provided a uniquely valuable experience for them.

Without the imaginative and dedicated assistance of Major Sanford Kozlen (AFBRMC), this project would also have been impossible. He made possible the timely acquisition of massive amounts of data in the form of computer tapes; he located and

furnished manuals, documents, regulations, and other source material vital to our analysis; he provided valuable contacts with Air Force, Army, Navy, and DSA personnel who are knowledgeable in the field of inventory management; he arranged for the visit to the Academy by senior GAO personnel. Since a detailed list of services performed by Major Kozlen would fill several pages, suffice it to say that--were it not for his assistance--Project "EOQ" would have produced just another "ivory tower" research tome to gather dust in someone's bottom drawer.

Among the dedicated professionals whose interest and assistance were critically important to the successful conclusion of this project are: Lt Col John Slinkard (AFLC/PPP), who initiated the research effort and provided continuing support; Mr. Paul Ste. Marie (AFLC/MMR), who made two visits to the Academy and whose suggestions and criticisms were invaluable; Mr. Arnett Burrow and Mr. Ray Robertson (GAO); Mrs. Elsie Akisada (Ogden ALC/MMR); Mr. Phil Jorgenson (Ogden ALC/PP); Mr. Bob Stevens (AFLC/ACD); Mr. William York (Ogden ALC/PP); and Mr. Richard Tingey (Ogden ALC/MMR).

At the Academy, Col Marcos E. Kinevan (Professor and Head, DFEGM) and Col. Stephen E. Schoderbek (Chairman, Economics and Management) provided the resources and the support for this unique experiment. Lt Col Douglas Johnson and his personnel of the Education and Research Computer Center made available large amounts of computer time and expert consulting services.

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CHAPTER I: INTRODUCTION

Project "EOQ" was initiated in January 1974 at the request of Headquarters, Air Force Logistics Command, and under the sponsorship of the Air Force Business Research Management Center. In a unique experiment, the Spring 1974 version of Management 534 (the Air Force Academy's graduate-level course in logistics management) was oriented toward the analysis of this large scale inventory management problem. The nineteen senior cadets enrolled in the course enthusiastically indorsed the idea, and since additional instructor resources were made available, this proposal to blend actual defense-related research with academic training was approved.

The original objective of Project "EOQ" was an investigation of the feasibility of installing a price discount solicitation capability in AFLC's procurement system for non-reparable spares. However, the charter was later broadened to include an analysis of the basic parameters used in economic order quantity (EOQ) computations. Since three of the officer members of the team had previous experience in AFLC, since all nineteen cadets had been exposed to the principles of inventory theory in previous Academy courses, and since the problem was well suited to

disaggregation for analysis by small teams, the requirements matched the available resources admirably.

The research phase of the project was concluded on 17 May, and a formal briefing was presented by the cadets to Mr. R. L. Stanley and other senior AFLC managers on 22 May 1974 at the Academy. Although all nineteen cadets involved in the project were commissioned as second lieutenants on 5 June 1974 and will report to their first Air Force duty assignments, the officer members of the team will assist AFLC through the summer in implementing the recommended changes.

The balance of this chapter will discuss the basic theory of EOQ computation and will present an overview of the report.

THEORY OF ECONOMIC ORDER QUANTITY

Optimal inventory management was one of the first successful techniques to be created by practitioners of operations research--a discipline that originated in World War II. In its simplest form, an inventory system involves purchasing, storing, and subsequently issuing items which are consumed by its "customers." Several costs are involved in such a system: the administrative cost of placing orders, the costs associated with holding items for issue, and the actual acquisition cost of the goods. Long before the advent of a mathematical model for inventory systems, successful managers intuitively realized that maintaining large stocks generates excessive costs. That is, high inventory levels created by large, infrequent orders tie up

investment capital, involve increased risk of obsolescence, and produce high storage costs. On the other hand, it was also realized that the proliferation of purchasing actions which results from attempting to maintain extremely low stocks generates excessive administrative costs. Therefore, managers attempted to find a compromise between extremes by a "seat of the pants" approach. Although it has subsequently been shown that this intuitive approach often produced results which were remarkably close to the optimal policy, such an approach was impractical for inventory systems involving large numbers of items and vast amounts of money.

The mathematical model for a basic inventory system is simple but elegant. Annual demand in units (D) for an item is assumed to be constant and known with certainty. Likewise, the purchase price per unit (P) is also a known constant. The administrative cost per order in dollars (C) and the holding cost as a decimal fraction of average inventory (H) are assumed to be computable from accounting records. The manager must determine the order quantity in units (Q) to be purchased each time an order is placed. Depending upon the decision as to the magnitude of Q, <u>the total annual cost</u> in dollars (TC) of ordering, holding, and acquiring the item becomes:

$$\text{TOTAL ANNUAL COST} = \text{ORDERING COST} + \text{HOLDING COST} + \text{ACQUISITION COST}.$$

Or, in mathematical symbols;

$$TC = \frac{CD}{Q} + \frac{HPQ}{2} + PD.$$

Note that, in the "total annual cost" formula for a specific item, the parameters D, P, C, and H are known constants--the only variable being Q, the order quantity.

Figure 1 displays graphically the three relevant costs as well as their sum.

FIGURE 1.--Cost Curves for the Basic EOQ Model

As is obvious from Figure 1, there is a unique order quantity for which the total annual cost is minimized, and this is the economic order quantity (EOQ). By the use of differential calculus, the following algebraic expression for this quantity is obtained:

$$EOQ = \sqrt{\frac{2CD}{HP}} \quad .$$

This is the classical formula for computing optimal ordering quantity.

The experienced manager will immediately indicate several objections--not to the mathematics, but to the underlying assumptions themselves. Demand is not always constant and is rarely known in advance; treating unit price as a constant does not allow for the consideration of price discounts; accurate computation of the ordering and holding factors may be difficult; no consideration is given to backorders. These objections are well taken, and operations researchers have developed sophisticated, highly complex mathematical models to deal with them. On the other hand, surprisingly good results have been obtained in government and industry by the use of the simple model described above. After all, even a gross approximation is often infinitely better than no system at all.

OVERVIEW OF THE REPORT

Chapter II outlines the background and history of AFLC's

EOQ system, discusses the construction of a baseline model to represent the present system, and indicates the effects of recent changes made by AFLC. A discussion of the role of standard price is also included here. The theory of price discounts, a simulation of their effect on the EOQ system, and a discussion of the results of an ongoing test at Ogden ALC are dealt with in Chapter III. Analyses of holding costs and demand prediction are presented in Chapters IV and V, respectively. Chapter VI is devoted to a discussion of composite results of the suggested changes and to the recommendations and proposals for implementation generated by this research effort.

Seven appendices contain technical discussions and ancillary material. Appendix A deals with the subject of ordering cost, and Appendix B examines the effect of relaxing the three-month and three-year buying restriction in DODI 4140.39. The mathematical description of the actual computer simualtion model itself is presented in Appendix C. Appendix D gives a detailed description of the procedures employed in the "Ogden test," and specific computational approaches used to generate the variable obsolescence rate matrix are explained in Appendix E. A short synopsis of the complex field of mathematical forecasting theory is included as Appendix F. Justification for the team's recommendations with respect to variable safety levels is offered in Appendix G.

CHAPTER II: CURRENT AFLC EOQ SYSTEM

Project "EOQ" attempted to identify some potential areas for dollar savings within the EOQ system currently being used by AFLC for expendable items. This chapter will provide the background for the study by presenting the background of the current AFLC EOQ system and describing in detail the baseline model used in the study.

BACKGROUND OF EOQ SYSTEM

Expendable item management first became a concern for AFLC logisticians during the 1952-1953 time frame when Congressional concern sparked the action.[1] Items were divided into three cost categories, and high value items were separated for special controls. In addition, requirements were first computed for consumption-type items which included five quarters of demand from 1956-1957. Low value items (cost category III) were

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[1]This section is a summary of Coile, James T. and Dickens, Dennis D., "History and Evaluation of the Air Force Depot Level EOQ Inventory Model," unpublished master's thesis, 1974.

minimally managed with yearly reports from bases as to consumption rates.

At the same time these measures were being taken, the RAND corporation began an analysis of use of the EOQ system for the Air Force. The Air Force Supply Management Handbook endorsed the basic principle of EOQ but pointed out that (1) funds might not be available to purchase more than one year's supply, and (2) price discounts were not included in basic EOQ computations. RAND Researchers and HQ AFLC personnel concluded in 1958 that (1) demand was the most sensitive element in EOQ computations since it was very volatile, (2) realistic ordering costs were difficult to come by since they varied with number of items procured, and (3) that the holding costs should be divided into investment interest, obsolescence, and warehousing costs.

On 24 June 1958, the Department of Defense followed up AFLC's studies with DODI 4140.31, directing the use of EOQ principles for all agencies and depots. AFLC responded by computing reorder, holding, and shortage costs based on time studies, engineering estimates, and judgmental estimates. The cost to order so computed was $34 per order, with a holding cost of 13%. Of the 13%, 4.0% was interest on investment, 6.9% was obsolescence, and 1.8% was storage cost.

In November of 1958, AFLC began to move with its Economic

Order and Stockage Program. It had three phases: (1) use of 1957 procurement levels while new levels were being designed, (2) developing electronic data processing capability to use cost factors in computing EOQ, and (3) cost studies by item for each item with high dollar issues. By July 1959, phase II had become bogged down, and funding limitations once again entered the picture. By 1960's evaluation, target date for action had been postponed until FY 63.

A Materiel Evaluation Group staff study for HQ USAF in the Economic Order and Stockage Program in 1961 concluded that there was considerable variation from true EOQ, resulting in AFLC's holding a greater inventory than was economically dictated. In response to this situation, AFLC sought to design an EOQ formula which avoided having to compute precisely the cost to order and the cost to hold. Instead, it computed a ratio of cost to order to cost to hold for each relevant range for use within the EOQ formula. With respect to this computation, the Materiel Evaluation Group suggested that five years' and one year's demands be the restrictions on range for EOQ to avoid technological obsolescence. This first use of EOQ, however, was marred by its assumption of annual demand equal to EOQ equal to $1000.

AFLC responded with concern over the arbitrariness of the analysis and of the dollar values. The principle was finally

accepted with proposed implementation date being FY 64. A second study recommending change in demand prediction was rejected by AFLC in favor of the moving average.

Implementation of the EOQ Buy Computation System in late 1963 or early 1964 was as proposed. Although the one year constraints were waived for awhile for annual demands over $1,000, they were reinstated in 1966 because of SEA requirements. AFLC analysts in 1966 pointed out that the single ordering cost and use of outmoded prices (and not soliciting price discounts) were the largest problems in the system. They suggested computing accurate ordering cost, developing a measure of relative dispersion to aid demand prediction, and continuing the one year minimum buy restriction. Because of funding limitations and stock buildups, waived again in 1967 to twice per year for items with annual demands over $1000.

In 1968 the General Accounting Office entered the picture by criticizing ordering and holding costs' being used by AFLC. AFLC responded in the negative by pointing to the lack of study in the area and the lack of theoretical sensitivity in the EOQ formula. In February 1968, the Air Force revised these figures in response to an invitation by the Assistant Secretary of Defense (Installations and Logistics) to serve on an _ad hoc_ DOD EOQ review committee. The ordering costs were

for the first time segmented into under \$2500 (\$162), call-type contracts (\$306), and over \$2500 (\$413). Cost to hold was 16%, with interest on inventory 10% and obsolescence 5%.

In July 1970, as a result of the ad hoc committee, DODI 4140.39 (Procurement Cycles and Safety Levels of Supply for Secondary Items) was issued, giving specific implementation guidelines for the EOQ system. New ordering costs of \$127, \$281, and \$379 were computed, and holding costs increased to 39% because of a 28% obsolescence cost.

CURRENT STATUS OF THE EOQ SYSTEM

DODI 4140.39 instructs all agencies to minimuze the total of variable ordering and holding costs, subject to a constraint of time-weighted, essentiality-weighted requisitions short. It also directs price discounts and incremental deliveries to be considered for incorporation into the ADP planning systems.

Concerning variable costs to order (or ordering costs), the DODI directs that three ordering costs be developed: for small purchases (less than \$2500), call-type contracts (basic ordering agreements), and for purchases greater than \$2500 (where negotiation or advertised procurement is used). In addition, a cost per item is determined by dividing the cost per document by the average number of items per document usually ordered by that section. Finally, the DODI directs reevaluation every two years

or as often as general schedule wages change.

Concerning variable cost to hold (or holding cost), the DODI instructs the breakdown into the three components of investment cost, storage cost, and obsolescence cost. The investment cost is set at ten percent since each public dollar invested in inventory is a dollar of investment in the private sector foregone. Storage cost is set at one percent as a result of industrial engineering studies by the DOD. Finally, obsolescence cost is the quotient of the annual transfers to Property Disposal Officers and stratified on-hand and on-order assets. A review is required annually on obsolescence costs.

The General Accounting Office (GAO) once again did a study in 1973 to determine whether or not the various agencies had complied with the provisions of the DODI. Their conclusions included the fact that cost factors in many cases were not current, an inadequate number of factors are used to accurately reflect costs, price discounts were not solicited, reparable items were not subject to EOQ computations, and buy guidelines were being used to constrain EOQ purchases. Ordering costs and obsolescence factors were found to be outdated, and the GAO recommended a breakdown of holding costs into more than one category.

OCAMA's and AFLC's responses to the report included the fact

that ordering and holding costs had been changed (from 39%, $127, and $379 to 32%, $142, and $424, and to 24%, $149, and $444 in early 1974). Also, reparable items involved inherent constraints on purchases that did not allow them to be purchased under EOQ. Buy guidelines that restricted quantities purchased in order to meet fiscal requirements were suspended indefinitely.

The remainder of this chapter describes the baseline model made to resemble the current EOQ system (D062), explains the sampling procedure used and the sample obtained, and presents some preliminary results

BASELINE MODEL

The baseline model was constructed to closely parallel the calculation of EOQ buy quantities in the D062 system. Even though the D062 system uses a table to develop the EOQ after annual demand and unit price are obtained from the master EOQ files, the baseline model made the EOQ calculation and then adjusted it if the EOQ was less than three months worth or greater than three years worth. The calculation used is the same as is used to create the table used by the D062 system and makes use of the EOQ formula described in Chapter I. Once the annual dollar cost for each item in the sample was calculated, it was then projected to the entire AFLC EOQ inventory. This model was then used as a control to compare the effects on annual

cost for AFLC by incorporating the changes that will be described in subsequent chapters.

SAMPLE

A random sample of 9,767 line items was drawn from the AFLC inventory (represented by the D062 master file from all five ALC's as of 31 December 1973). The sample was stratified by annual dollar demand into nine categories. Table 1 shows the nine categories, the annual dollar demand breakouts, and the percentage representation of the population in the sample. Table 2 shows the number of items in each category and the final total of 9,767 items. The ninth category--all items with greater than $45,000 annual dollar demand--does not contain I&S items. The ninth category, therefore, contains 100% of all AFLC's bachelor EOQ items; the random computer sampling procedures used on the other eight categories were not affected by the exclusion of I&S items. The sample obtained represents almost half of the AFLC inventory in terms of annual dollar demand and was used to test all models. The dollar cost saving obtained by each model was projected to estimate the dollar cost saving that would be obtained for the entire AFLC inventory.

TABLE 1

SAMPLE STRATIFICATION

CATEGORY	ANNUAL DOLLAR DEMAND	% IN SAMPLE
1	less than $25	1%
2	$25 to $100	2%
3	$100 to $500	2%
4	$500 to $1000	5%
5	$1000 to $2500	5%
6	$2500 to $5000	10%
7	$5000 to $10000	10%
8	$10000 to $45000	33%
9	greater than $45000	100%*

*This figure is actually 82% of the total AFLC inventory because (I&S) items were excluded.

TABLE 2

SAMPLE ITEM BREAKOUT

CATEGORY	ITEMS IN SAMPLE	ANNUAL DEMAND
1	628	$ 5,470
2	1056	50,814
3	1249	260,119
4	1127	703,879
5	1074	1,497,127
6	927	2,830,604
7	686	4,155,284
8	1851	31,325,337
9	1169	124,941,431
TOTAL	9767	$165,770,065

PRELIMINARY RESULTS

Since the last two changes in ordering costs and obsolescence rates occurred during the process of the study, these changes were analyzed to determine the effect on annual

dollar cost to AFLC and on the total annual number of buy actions. Table 3 exhibits the effect of the two most recent changes in ordering and holding parameters. From Table 3 it is evident that AFLC has been moving in the right direction. Savings of $1.1 million were realized in total annual cost by the first parameter change, and additional savings of over $4.5 million resulted from the second change. Moreover, the number of buy actions has also been reduced. (Each buy action represents the necessity of a procurement action for this item and is not to be misconstrued to mean a "buy" in the current AFLC sense).

Two other minor changes were made to the model to analyze their effects. In the first case, the three-month/three-year buy restrictions in DODI 4140.39 were relaxed. The results of this change are described in Appendix B. The second change involved use of the acquisition price in the EOQ calculation rather than its standard price obtained directly from the item master record. AFLC, being a wholesaler, adds a 15% surcharge to the acquisition price and uses this standard price to charge its customers. The EOQ formula requires the use of the best known purchase price, but the D062 system uses the standard price. The effect of the procedure is inaccurate calculation of the EOQ quantity, which results in increased costs. Specifically, AFLC incurs additional costs of over $120,000 annually and increases the number of item buy actions by 7% by this practice.

TABLE 3

ANNUAL COSTS
(Projected For the Entire Inventory)

MODEL	ACQUISITION COST	HOLDING COST	ORDERING COST	TOTAL COST
PRIOR TO JUNE 1973	$348.9 Million	$28.6 Million	$30.3 Million	$407.8 Million
JUNE 1973-MARCH 1974	$348.9 Million	$26.9 Million	$30.9 Million	$406.7 Million
APRIL 1974-PRESENT	$348.9 Million	$23.8 Million	$29.5 Million	$402.2 Million

Using the baseline model as a control, the subsequent chapters will analyze the effects of price discounts, variable obsolescence, better demand prediction, and the combination of all three proposed changes. The next chapter analyzes the effects of price discounts.

CHAPTER III: PRICE DISCOUNTS

It is axiomatic that the keys to the phenomenal success of the American industrial system are mass production and increasing productivity. In this chapter a discussion of the relationship between the theoretical foundations for these phenomena (economic production quantity and economic purchase quantity) will precede an analysis of price discounts as they apply to AFLC's EOQ system. The test of an actual price discount solicitation program at Ogden Air Logistics Center is examined, and recommendations for installation of a similar system at all ALC's are outlined.

ECONOMIC PRODUCTION QUANTITY

One does not need to be a professional economist to understand the basic theory of economic production quantity (E Pro Q). The manufacture of goods involves two kinds of costs--fixed and variable. Fixed costs are incurred as a result of setting up a production line for operation (e.g., obtaining the appropriate machinery and producing dies) and must be incurred regardless of the number of units eventually produced. Variable costs are directly related to the quantity produced and include such

elements as materials and direct labor. Thus, the average production cost for each unit produced is merely the sum of fixed and variable costs, divided by the total number of units manufactured. Obviously, as the size of the production run increases, the portion of fixed cost allocable to each unit decreases; on the contrary, as production increases beyond the "normal" capacity of a plant, overtime and other costs are incurred that cause an increase in the per-unit variable cost. The result, as illustrated in Figure 2 , is an "average cost of production" curve which indicates the economic production quantity (E Pro Q).

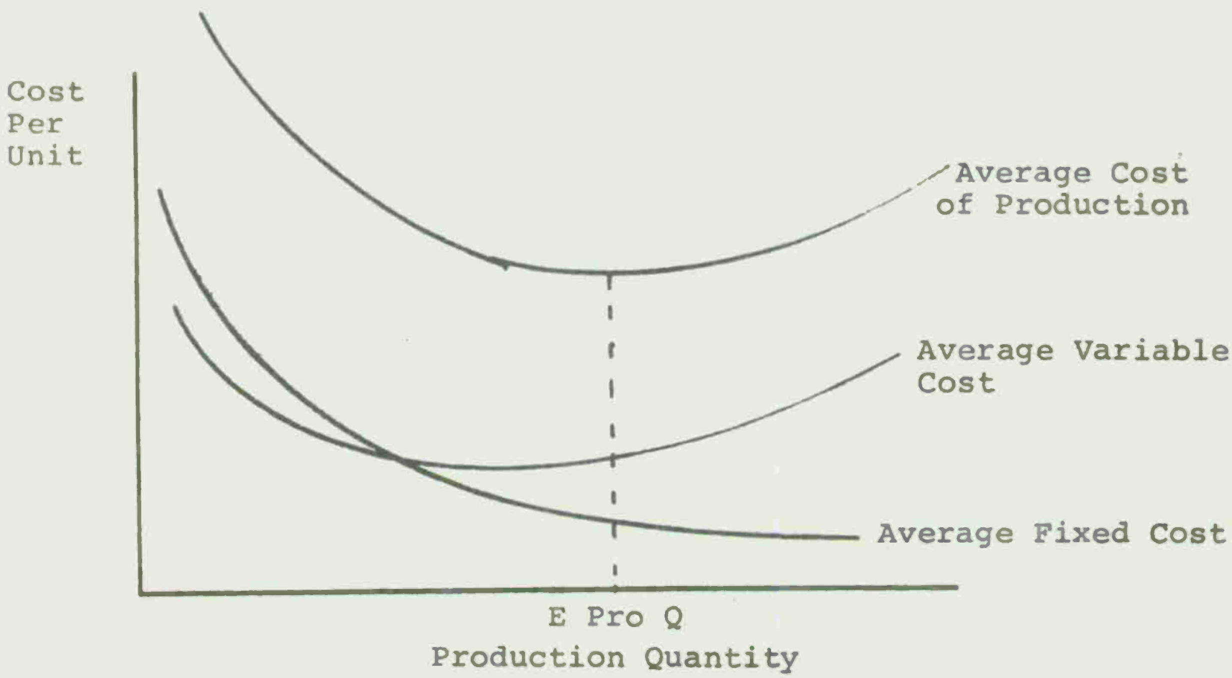

FIGURE 2.--Cost of Production Curves

The goal of the producer is to schedule production runs so that the quantity to be manufactured is as close to the E Pro Q as possible. If the item to be produced is a widely used commercial item, the line manager may attempt to pool several small orders (or subcontract a very large order) in order to schedule a single economical run. In Project "EOQ," most items in the non-reparable spares category are parts for various weapons systems and, as such, generally have little or no commercial application. Thus, the AFLC practice of soliciting bids on quantities determined <u>internally</u> ignores E Pro Q considerations entirely. Stated simply, if the quantity ordered by AFLC is significantly below the producer's E Pro Q, then he must charge a higher price in order to manufacture items efficiently. After all, the government must pay the fixed, or setup, cost regardless of the quantity it orders. There is an alternative to the present system, however, in employing the device known as economic <u>purchase</u> quantity.

ECONOMIC PURCHASE QUANTITY

The basic theory of the economic purchase quantity (E Pur Q) is as straightforward and easily understood as its counterpart in production. The purchaser--cognizant that his internally computed EOQ may not coincide with the producer's E Pro Q--solicits price discounts for larger orders. If one of these

order quantities roughly equals the producer's E Pro Q, then the purchaser expects to share the savings attained by more efficient production through a price break on the acquisition cost. Naturally, the purchaser must consider the elevated holding costs occasioned by a larger order; the mathematical tools for evaluating the feasibility of accepting the proffered discount are will developed.

Basically, there are only two widely recognized methods for soliciting price discounts--incremental and all-units. Incremental discounts are stated in terms of decreased unit prices for ranges of quantities; that is, a higher <u>increment</u> receives a decreased price only for the portion of the order which intersects that increment. For example, an incremental price discount quotation might appear as follows:

FOR UNITS BETWEEN:	UNIT PRICE IS:
0 and 100	\$500
101 and 300	\$450
301 and 1000 (max)	\$405

In this example, the decision to order 200 units would result in an <u>average</u> unit price of \$475. Given this price information, the purchaser would compute the E Pur Q with a formula similar to the EOQ formula discussed in Chapter I. Although this formula is somewhat more complicated than the simple EOQ formula, mathemati-

cal complexity is not the drawback to incremental discounts as they apply to government procurement.[1] Experienced buyers will recognize incremental discount solicitations as being similar to indefinite quantity (IQ) procurements. Since the E Pur Q can be any quantity in the overall range solicited, the difficult problem of equal treatment of bidders in a competitive solicitation arises. For instance, an award to Company A in the previous example might be determined on the basis of lowest total cost and for an order quantity of 250 units. Company B, whose bid resulted in an "optimal" order quantity of 200 units, but whose total annualized cost was greater than that of Company A, might protest the award on the basis that he was not offered the opportunity to bid on a quantity of 250 units! Although such a

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[1]E Pur Q = $\sqrt{\dfrac{2D\left[C + \sum_{i=1}^{n-1} Q_i\,(P_i - P_{i-1})\right]}{H\,P_n}}$, where

P_i = incremental price for $Q_{i-1} \leq$ order quantity $\leq Q_i$.

protest may seem illogical from a mathematical standpoint, ASPR provisions concerning "fair and equal treatment" could be interpreted to support Company B's position. For this reason, solicitation of incremental price discounts for procurement of non-reparable spares is not recommended.

Fortunately, all-units discounts do not broach the legal difficulty mentioned above. For example, an all-units price discount quotation might appear as follows:

IF THE ORDER QUANTITY IS BETWEEN:	UNIT PRICE FOR ALL UNITS IS:
0 and 100	$500
101 and 300	$475
301 and 1000 (max)	$440

Interestingly (and fortunately), the E Pur Q in this case can occur only at four specific order levels: the original EOQ, 101 units, 301 units, and 1000 units. Although this statement can be proven mathematically, it is demonstrated more easily in Figure 3, which exhibits the effect of a single all-units price discount. In this example, the quantity identified at the E Pur Q is obviously the most economical quantity to purchase, since the savings available from the decreased purchase price more than offset the increased administrative (holding) costs incurred. Furthermore, note that, if the price discount had been offered for a purchase quantity greater that the quantity

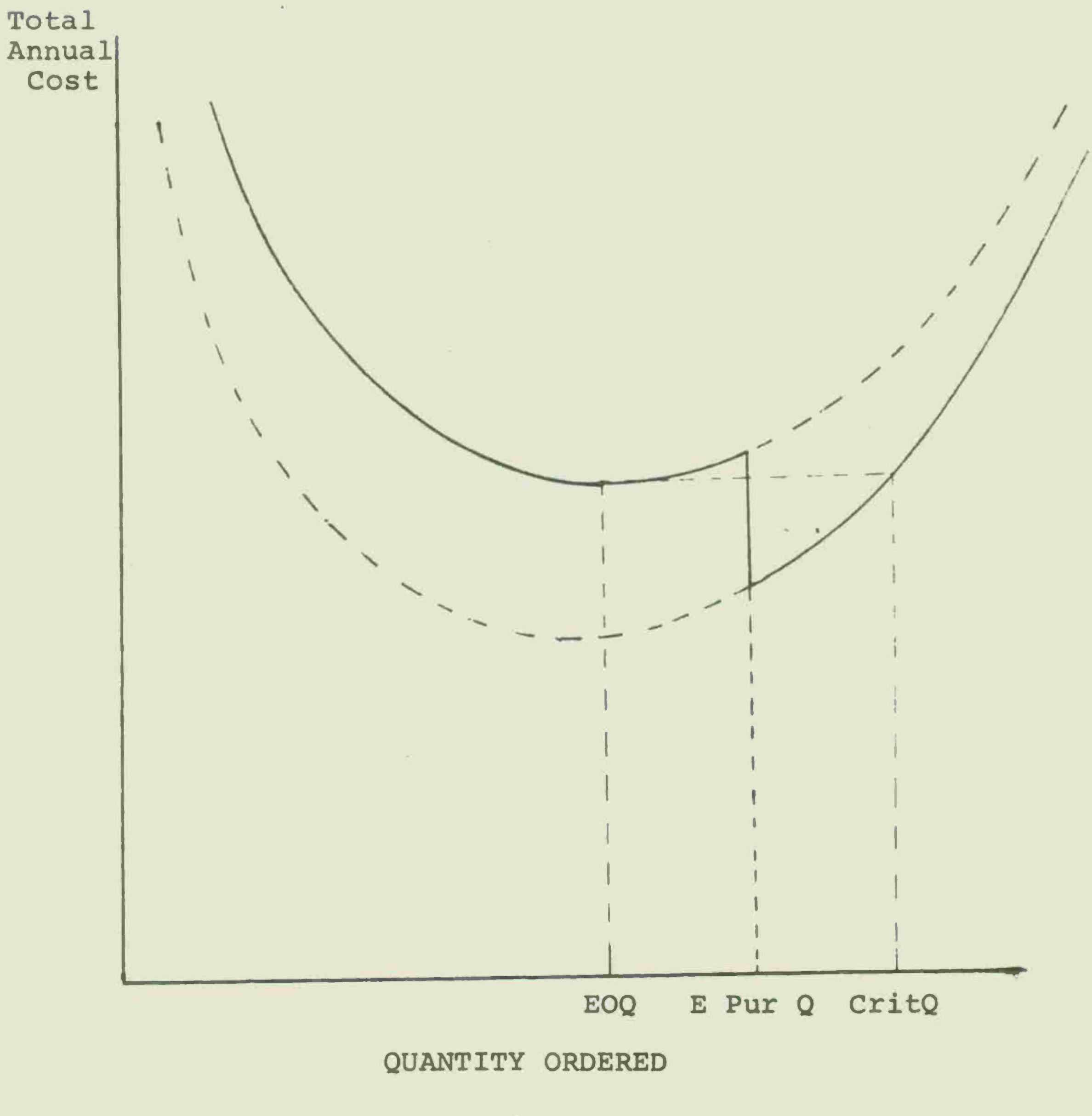

FIGURE 3.--Cost Curves for a Single All-Units Price Discount

labeled "CritQ," then taking advantage of the price discount would not prove to be economical, and the E Pur Q would be the original EOQ. Thus, it is apparent in this example that only two purchase quantities can be optimal--the quantity at which the price discount occurs and the original EOQ. In general, if N all-units price breaks are solicited, then only N+1 purchase quantities can be optimal, and these quantities are the original EOQ and the N break quantities.

The ramifications of this feature of all-units price discounts are obviously fortuitous in the present case. The minimum quantity to be solicited by AFLC is the EOQ quantity; the maximum quantity to be solicited is determined by DODI 4140.39 constraints, fiscal considerations, or other internal factors. Intermediate solicitation quantities are chosen so as to be "reasonable." All competing firms are offered identical predetermined quantities on which to bid; the award is determined on the basis of the quantity which yields the lowest total annualized cost.

The recommended form to be used for soliciting all-units price breaks is shown as Figure 4. Two important features of this attachment to the solicitation should be noted: first, the bidder may indicate price discounts on any or all of the quantities listed and still be responsive; second, the government

NOTICE TO OFFEROR

Solicitation Number________________.

In order to take advantage of price discounts, it may be economical for the government to purchase a quantity larger than that stated in item No.__________ of this solicitation.

If you offer price discounts on this item when purchased in larger quantities, please indicate the per-unit price for one or more of the following quantities.

	QUANTITY IN UNITS	PRICE PER UNIT
(Original Quantity)	______________	$______________
	______________	$______________
	______________	$______________
	______________	$______________

Where budgetary limitations permit, the purchase quantity will be determined using the criterion of lowest annualized total cost to the government. This total cost includes holding and ordering costs as well as the actual cost of the items themselves.

FIGURE 4.--Recommended Form for Solicitation of Price Discounts

clearly indicates its option to purchase any of the quantities stated. In regard to the first feature, note that the bidder need not make a single entry on the form (as long as he fills in the original schedule) to be responsive. With reference to the second feature, temporary funds shortages may obviate the decision to purchase the best quantity, but a lesser quantity may be ordered from the bidder indicating the lowest unit price for that quantity. Finally, the applicability of this approach to single source procurements is obvious.

In this "back door" approach to the problem of matching E Pur Q with E Pro Q, the solicitation of price discounts on larger quantities will not always meet with success. For example, if the EOQ is already fairly close to the bidder's E Pro Q (e.g., small business), then the probable response will be a blank price discount solicitation form. In another instance, even the largest quantity solicited may be uneconomical to produce, and the bidder may decline to differentiate between "inefficient" and "very inefficient" quantities as to price. In many cases, however, solicitation of price discounts results in savings to both the government and the manufacturer through the realization of production efficiencies.

In the private sector, price discount solicitation is commonplace, but the information on average discounts offered is

obviously proprietary. Therefore, in an effort to assess the overall effect of price discounts on AFLC's EOQ system, a simulation approach was adopted.

THE PRICE DISCOUNT SIMULATION

A computer simulation of price break solicitation for non-reparable spares buys was performed in an effort to determine the resulting economic impact on the EOQ system. (Appendix C contains a mathematical description of the simulation model). Since the only information available with respect to price discounts in this environment was in the form of data supplied by the GAO,[2] it was decided to simulate price discounts averaging 3%, 5%, and 8% on sequential solicitation quantities. The model was run on the 9,767-item sample discussed in Chapter II, and the sample results were projected mathematically to the entire EOQ system. In these simulations, the current AFLC parameters for holding and ordering costs were used, and the only change (other than price discounts) was the use of actual purchase

[2]Working papers used in a test similar to our Ogden test were supplied to the team during a visit to the Academy by Mr. Arnett Burrow, Deputy Director of the Kansas City Regional Office of GAO. Twenty-three price breaks averaging 7.2% were noted, with the maximum discount being 31% and the minimum being 1%.

price (rather than standard price) to compute the EOQ and E Pur Q. The results of these simulations are displayed in Table 4 .

TABLE 4

SAVINGS AVAILABLE THROUGH PRICE DISCOUNTS IN AFLC'S EOQ SYSTEM

AVERAGE PRICE DISCOUNT	GROSS SAVINGS [a]	ADDITIONAL HOLDING COST INCURRED	NET SAVINGS [b]
3%	$19.6 Million	$ 9.3 Million	$10.3 Million
5%	$39.9 Million	$14.0 Million	$25.9 Million
8%	$67.2 Million	$16.5 Million	$50.7 Million

[a] Actual savings in acquisition cost

[b] Gross savings less increase in holding costs

Although the level of savings available through price discount solicitation is startling, it should be noted that a conservative approach was taken in building the simulation model (Appendix C). Thus, the projections in Table 4 could easily be understated if a more favorable price discount opportunity actually exists. Evidence from the Ogden test seems to bear out this possibility.

THE OGDEN TEST

The Ogden Test was designed and initiated with the objective of obtaining factual information to augment the results of the AFLC price discount simulation. More specifically, the goal of this test was to acquire the needed data on price discounts with a minimum of disruption to current AFLC procedures. Thus, test simplicity and efficiency within legal requirements became the key parameters of this endeavor. Further, should the test prove to be successful, these procedures could be assimilated throughout AFLC with very little difficulty. (See Appendix D for test details).

Once approved by AFLC Headquarters, the test and its objectives were briefed to Ogden Materiel Management and Procurement executives in late March 1974. However, full test implementation was delayed until specifics could be coordinated between these Ogden agencies.

Since the majority of dollars spent on EOQ items is for aircraft related spares, for the purposes of this test it was decided to include only the EOQ buys for the Ogden F-4 and Landing Gear Divisions. In mid-April, after administrative matters had been coordinated, F-4 and Landing Gear EOQ item purchase requests (PR) with test forms included (See Appendix D)

began to go out for bid. The test forms were to give the contractor the opportunity to respond to a solicitation that offered more than one PR quantity. As previously stated, the contractor might find it economical to produce more than what the government considered its EOQ quantity to be. Consequently, cheaper production costs due to economies of scale could be passed on to the government in the form of price discounts.

Data were collected from the time the test was started in mid-April until mid-June. This sample of actual data provides significant support for the assumptions inherent in the simulation. For purposes of this research, data will be collected until 30 June. To date, solicitations with requests for price discounts were sent out by Ogden buyers on 52 items. Of this total, 14 have been returned, and price discounts were received on 10 items. The mean price discount on these solicitations was 4.5%. Thus, on the strength of a sound theoretical base and the previously mentioned date, the following recommendations are made.

RECOMMENDATIONS

1. Since there is ample evidence that price discounts can save money when purchasing EOQ items, and further, since the Ogden test confirms AFLC's ability to successfully solicit price discounts, it is recommended that AFLC proceed with the necessary

action to implement techniques and policy that will take advantage of these savings.

2. Until AFLC implements a price discount capability, it is recommended that the Ogden test be continued for the purpose of gaining information on price discounts.

CHAPTER IV: HOLDING COST ANALYSIS

This analysis was conducted with the objective of identifying those areas of holding costs which might lend themselves to more accurate determination. The rationale of this approach was that any increased accuracy that could be obtained would be used to calculate a more accurate and, therefore, lower cost economic order quantity (EOQ). To arrive at this objective, each of the elements of AFLC's holding cost (H = h+I+0, where I is investment or opportunity cost, h is storage cost, and 0 is obsolescence cost) were analyzed.

ELEMENTS OF HOLDING COST

Holding costs are generally thought to increase directly or linearly with increases in quantity. Industry usually computes holding costs as a percentage of on hand inventory for each item in the inventory system. In other words, within each item category there is a specific holding cost factor.[1] As each item

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[1] $EOQ_i = \sqrt{\dfrac{2D_iC_i}{H_iP_i}}$, where D_i is specific item demand, C_i is specific ordering cost, P_i is specific item price and H_i is specific holding cost for this item.

has a unique price and demand, it follows that each item, given H = I+h+O, has a unique holding cost. AFLC uses one holding cost for all EOQ items. If average holding cost as a percentage of total inventory is computed to be 24%, AFLC applies this percentage to each EOQ computation. However, the only time this approach is correct is if inventory is homogeneous. Thus, considering these facts, an analysis of the various elements of AFLC's holding cost was accomplished.

INVESTMENT, STORAGE, AND OBSOLESCENCE COST

To facilitate the analysis, holding costs were broken down into the individual component costs of investment, storage, and obsolescence costs. In the studies made of each component cost, emphasis was placed, first of all, on the determination of the necessity for each component in the EOQ calculation, and secondly, on the rationale behind each component's calculation. Stated in another manner, an evaluation was made on each component cost to determine how well it indicated what it was designed to show.

In the analysis of investment cost, it was found that Department of Defense Instruction (DODI) 4140.39 directed that a 10% investment charge on the average on hand inventory be taken in order to account for the opportunity cost of investing in inventories. DOD's rationale behind this directive was that

each dollar of investment in inventory was a dollar of investment foregone in the private sector. As to the magnitude of the 10% figure, the General Accounting Office (GAO), in its November 1973 report on the use of the EOQ principle, agreed with the 10% charge. Additional evidence supporting both the inclusion of the cost and its magnitude was noted in a paper written by Dr. Jacob A Stockfisch, economist and Senior Research Associate/ Member for the Institute for Defense Analysis. Dr. Stockfisch contends that a 10% rate is reasonable for use with government investment and represents the expected return if funds were available for investment in the private sector of our economy. Based upon this information, a 10% cost was considered to be both a necessary charge and a reasonably accurate estimate of investment cost.

A study of storage costs indicated that DODI 4140.39 directed the inclusion in storage costs of such items as: care of materiel in storage, rewarehousing costs, cost of physical inventory operations, preservation and packaging, training of storage personnel, cost of warehousing equipment, prorated base services, and overhead costs. The GAO, in its November report, concurred with Air Force Logistics Command (AFLC) in its use of a rate ranging from 1-1 1/2%. Based on the GAO evaluation and our conclusion that any change made in the calculation of such costs would involve a negligible amount, it was decided that the

figure appeared to be a reasonable approximation of the actual storage costs.

The study of obsolescence costs indicated that a single rate of obsolescence was used for all EOQ items in the AFLC inventory. This practice seemed puzzling because of the fact that not all of the inventory items have the same rate of obsolescence. Referring to DODI 4140.39, it was found that each Inventory Control Point (ICP) is required to calculate separate obsolescence rates for the items which it manages. Further breakdowns, such as by commodity grouping, were authorized by this instruction, particularly for those classes of materiel subject to rapid technological change or rapid deterioration. Neither of these control techniques are being used at present.

When this study began in early January, the obsolescence rate used for all Air Force inventory items was 21%. This figure has since been reduced to 13%. In the GAO study, it was recommended that the costs of obsolescence be allocated to those items in which obsolescence actually occurred. With the present system, the EOQ calculation is distorted, in that those items with high obsolescence do not have a sufficiently high obsolescence rate charged to them. This fact results in an increase in the calculated EOQ over what it actually should be. The effect is just the opposite in the case where an excessive obsolescence

rate is charged; the calculated EOQ is less than what it actually should be.

On the basis of the above analysis, it was believed that a significant improvement could be made in the calculation of obsolescence rates. Therefore, it was decided to focus efforts on this area of holding costs.

VARIABLE OBSOLESCENCE

As previously mentioned, a constant holding cost factor would be appropriate if AFLC's inventory were homogeneous. Since it is not homogeneous, it follows that holding cost must vary with the specific item being considered. In the foregoing paragraphs it has been shown that investment cost and storage costs can be considered constant but that obsolescence costs cannot be allowed this latitude because of their direct effect on the calculation of EOQ. Therefore, it seemed logical to pursue a method by which AFLC could calculate and use a variable obsolescence rate.

The study team looked at several methods of computing variable obsolescence. The one that seemed to offer the most promise was an approach which we called a Variable Obsolescence Matrix (VOM). Once data became available, this was the method that was used to calculate variable obsolescence. (See Appendix E for details on VOM). This method involves building a matrix of Federal Supply Class (FSC) codes and System Management codes

(SMC) and calculating the obsolescence rate for each matched pair. (See Appendix E for calculations). Thus, this matrix delineates the obsolescence rate for a specific weapons system within a homogeneous supply class. Although this stratification system is still general in nature, it is much more specific than the obsolescence rates currently used to calculate EOQ. This technique was tested by using the results of variable obsolescence research in a simulation.

SIMULATION RESULTS

This simulation performed to test the VOM approach is an extension of the baseline model to include price discounts as developed in the discount simulation and variable obsolescence rates as computed in this portion of the study (See Appendix E). Computations were made to measure the impact of these changes. The aforementioned 9,767-item sample was used to represent the AFLC EOQ inventory. As previously stated, this sample represents approximately 40% of the dollar cost of EOQ items. The following results were obtained.

Total cost for the sample using current AFLC criteria for the purchase of EOQ items was $177,150,552.00. However, when this "baseline" model was modified to reflect the applicable

variable holding costs, total costs dropped to $173,407,985.[2] Thus, by implementing the variable obsolescence rate concept and not other changes, $3,742,567 can be saved on the items in the D062 sample. Extrapolated to include all AFLC EOQ items, net savings would be approximately $7.68 million.

Further, when the variable obsolescence rate concept is combined with the price discount simulation, significant savings can be realized. Using average discounts of 3%, 5%, and 8%, the following results (see Table 5) were obtained by extrapolating the data in the sample to include all AFLC EOQ items.

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[2]Recall H = h+I+O; in this model h (or storage cost) is maintained at 1%, I (or opportunity cost) is maintained at 10%, and O (obsolescence cost) = V(O), the variable obsolescence function. That is, H = .11 + V(O).

TABLE 5

SAVINGS AVAILABLE THROUGH VARIABLE OBSOLESCENCE AND PRICE DISCOUNTS IN AFLC'S EOQ SYSTEM

AVERAGE PRICE DISCOUNT	GROSS SAVINGS	ADDITIONAL HOLDING COST INCURRED	NET SAVINGS
NO DISCOUNTS	\$ 7.86 Million	0 Million	\$ 7.86 Million
3%	\$23.41 Million	\$6.00 Million	\$17.41 Million
5%	\$43.02 Million	\$7.45 Million	\$35.57 Million
8%	\$69.21 Million	\$7.37 Million	\$61.83 Million

RECOMMENDATIONS

1. A variable obsolescence rate should be used for making the EOQ calculations.

2. The Variable Obsolescence Matrix should be used as a management tool to identify those items which are running an excessively high obsolescence rate.

3. Obsolescence rates should be updated quarterly.

However, these results will have only a moderate effect unless reasonable demand predictions are used. This topic is addressed in the next chapter.

CHAPTER V: DEMAND PREDICTION

Accurate prediction of demand is essential to efficient management of any supply network and, as such, deserves serious consideration. Without good estimates of future demand, the procurement cost cutting efforts in other areas of EOQ management will not succeed.

This chapter will first comment on the nature of demand in AFLC. Next it will propose a method of categorizing items by their demand history in order to better manage them. Next, it will discuss methods of predicting demand and the results that can be expected when good demand prediction techniques are used.

NATURE OF DEMAND

The nature of demand in the Air Force has never been a matter of great controversy. Research has consistently shown that there are large numbers of items with low or erratic demand histories. As far back as 1956, a RAND study by Bernice B. Brown had the following to say about demand for aircraft spare parts:

> Demand for most spare parts tends to be erratic. Even if the demand rate for a part is known for some past period, the future demand during a similar period cannot be predicted with accuracy....
>
> Low average demand rates are characteristic of a

> large portion of all aircraft parts....The slow moving, low-cost parts account for a small fraction of the total dollar value of issues, but because of their large number and, often, their essentiality to the functioning of the aircraft, they constitute a significant logistics problem.[1]

An AFLC study in 1967 further attested to the low, erratic demand of a significant number of Air Force items, as did a 1972 R&D working memorandum by R. G. Brown. Therefore, the first task was to find the proportion of items of this nature and some method of separating these items from the more predictable ones without affecting the validity of the model.

CATEGORIZATION BY DEMAND

It is doubtful if there is any one demand prediction technique that can predict equally well the future demand for such a diverse group of items as that managed by AFLC. The results of this study indicate that the demand patterns of the AFLC EOQ items fall into three broad categories: low, erratic, and predictable.

The first category, low demand items, includes those items with less than three quarters of positive demand history in the last eight quarters. Approximately 44% of all EOQ items

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[1]Bernice B. Brown, Characteristics of Demand of Aircraft Spare Parts, Santa Monica: The RAND Corporation, 1956, p. vii.

fall into this category. These items are generally in very good stock position, with 96% of them having two or more years worth of assets on hand or due-in. Thus, they should require very little management attention.

The second category, erratic demand items, had at least three quarters of positive demand history in the last eight quarters, but they have demand standard deviations greater than their average demand. These erratic demand items present special problems in demand prediction, particularly in determination of safety levels. (See Appendix G) Approximately 21% of the EOQ items fall into this category.

The third category of items are those that did not fall into the two previous categories and hence may be thought of as "normal" items or, more aptly, items with predictable demand. Approximately 35% of the EOQ items are in this category.

DEMAND PREDICTION METHODS

There are many possible methods of predicting demand. During the course of this study, five different methods were tested: moving average; single, double, and triple exponential smoothing; and linear regression analysis. Also, a special demand prediction method was investigated. (See Appendix F) The results of the study indicate that single exponential smoothing is, by far, the best overall predictor for both categories 2 and 3. Category 1 items have demand too low to predict with any kind of

acceptable accuracy.

Single exponential smoothing may be compared to a weighted moving average with the most weight placed on the most recent data and ever decreasing weight placed on the data the older it gets. By varying the value assigned to a "smoothing constant" one can increase or decrease the amount of weight assigned to the most recent data. If there has recently been a change in demand history, a higher smoothing constant will more quickly adjust the forecast to the new demand pattern. A low value for the smoothing constant is best when the demand is constant. A method that combines the best features of both a high and low value for the smoothing constant is proposed by Brown.[2] He recommends using a tracking signal with exponential smoothing in making forecasts and then shifts back and forth between high and low values for the smoothing constant in order to give the best forecast.

SIMULATION RESULTS

In order to test the new demand prediction technique, a

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[2]Robert G. Brown, "Smoothing, Forecasting and Prediction of Discrete Time Series," New York: Prentice-Hall, Inc., 1964, p. 287.

simulation was conducted using single exponential smoothing with a low smoothing constant for categories 2 and 3. For purposes of the simulation, all category 1 items used the moving average to forecast demands. The single exponential smoothing predicted significantly higher than the moving average on 28% of the items and significantly lower on 18% (a 25% greater difference was considered significant).

Table 6 gives the projected dollar savings if the new demand technique is implemented for different average discounts. The tracking signal was not used in this sample; if it had been, the results would have been even better. Table 7 gives the reduction in buys for the sample as a result of better demand prediction.

This simulation does not include a new variable safety level that was developed by the research team. Appendix G gives a detailed explanation of the proposed variable safety level, which promises to increase fill-rate while decreasing investment in safety levels.

TABLE 6

SAVINGS AVAILABLE THROUGH MORE ACCURATE DEMAND PREDICTION AND PRICE DISCOUNTS IN AFLC'S EOQ SYSTEM

AVERAGE PRICE DISCOUNT	GROSS SAVINGS	ADDITIONAL HOLDING COST INCURRED	NET SAVINGS
3%	$26.6 Million	$ 7.4 Million	$19.2 Million
5%	$48.8 Million	$13.3 Million	$35.5 Million
8%	$76.5 Million	$15.3 Million	$61.2 Million

TABLE 7

REDUCTION IN BUYS FOR THE EOQ SAMPLE

AVG. DISCOUNT	NO. OF BUYS	% OF BASE	CUMULATIVE REDUCTION
BASE	13,786	100	--
0%	13,615	99	171
3%	9,612	70	4174
5%	7,860	57	5926
8%	6,727	49	7059

RECOMMENDATIONS

The recommendations with respect to demand prediction are as follows:

1. Categorize all EOQ items into one of the three categories discussed above. Code all Category 1 items for management review in the D062 system so thay any requisition for these items will be reviewed by the IM prior to release if low priority, and after release if high priority. Since these items have such low demand, any demand is suspect, and the IM must insure that it is a valid requirement. Review all Category 1 items once a year or when requisitioned. Compute no levels or forecast any requirements for these items other than annually.

2. Use single exponential smoothing (with tracking signal to shift between high and low smoothing constants), for predicting demand Categories 2 and 3. The IM would have a manual override option with respect to the tracking signal.

3. Use a variable safety level as described in Appendix G.

CHAPTER VI: COMPOSITE RESULTS AND RECOMMENDATIONS

In the previous three chapters, projected savings for AFLC's EOQ system were exhibited for implementation of a price discount capability (Chapter III), variable obsolescence combined with price discounts (Chapter IV), and improved demand prediction with price discounts (Chapter V). This chapter displays the projection of savings attainable through implementation of all three recommended changes, presents an expanded discussion of recommendations, and indicates problem areas which must be dealt with in the course of implementation.

COMPOSITE SIMULATION RESULTS

A series of simulations were run with all recommended features included in the final model. For clarity, this final model includes the following changes to the present EOQ system:

1. Unit price, rather than standard price, was used to compute the EOQ;

2. Variable obsolescence rates computed from the DO62 system by FSC/SMC were used;

3. The new demand prediction scheme--not to include the tracking signal feature--was used to generate forecasted demands;

4. Average price discounts of 3%, 5%, and 8% were simulated.

The results of multiple runs of this final form of the simulation model are presented in Table 8.

TABLE 8

SAVINGS AVAILABLE THROUGH IMPLEMENTATION OF ALL RECOMMENDED CHANGES TO AFLC'S EOQ SYSTEM

AVERAGE PRICE DISCOUNT	NET ANNUAL SAVINGS
3%	$21.5 Million
5%	$39.6 Million
8%	$68.2 Million

Although the magnitudes of savings exhibited above speak for themselves, it is impossible at this point to resist a bit of hyperbole. The nineteen cadets who worked on this project, along with 800 of their classmates, graduated and were commissioned on 5 June 1974. The best current estimate of the total four year cost of producing an Academy graduate is $80,000. Thus, the Class of 1974 represents an investment of approximately $68 million. Given the conservative approach taken at every turn in this study, and given the empirical evidence which indicates the reasonableness of soliciting an average discount of 8%, the implication intended is obvious.

RECOMMENDATIONS

1. It is recommended that AFLC institute a system for

soliciting price discounts on non-reparable spares buys at all five ALC's on 1 July 1974. Recommended procedures for computing solicitation quantities are outlined in Figure 5 at the end of this chapter. The recommended solicitation form was exhibited as Figure 4 in Chapter III.

2. It is recommended that AFLC adopt the variable obsolescence rate computation procedure (as outlined in Chapter IV) immediately. The rates should be updated quarterly, since D062 tapes from the ALC's are available at HQ AFLC on a quarterly basis.

3. It is recommended that EOQ items be segregated into three categories (low demand, erratic demand, and predictable demand) for management purposes and that the prediction methods outlined in Chapter V be adopted as soon as possible.

4. It is recommended that further study of the use of multiple regression techniques to predict demand for high-dollar value aircraft spares be undertaken (see Appendix F).

5. It is recommended that the "Ogden test" be continued until 1 July 1974 in order to obtain additional data needed in the implementation of a price discount solicitation program at all ALC's.

6. It is recommended that further study of the use of variable safety levels be accomplished during July, 1974 (see Appendix G).

IMPLEMENTATION

1. The only apparent difficulty involved in implementing a price discount solicitation capability concerns administrative control of funds. Given that restrictions on obligation authority are removed (with the obvious exception of the fiscal year constraints imposed by Congress), the price discount program could be phased in on 1 July 1974 by initially restricting solicitation of discounts to those items which will normally be bought two or more times in FY 75. In this way, savings could be realized without the necessity for committing FY 75 funds for programmed FY 76 procurements. Later in FY 75, if savings accrue as expected, the solicitations could be expanded to include a larger subset of procurement actions.

2. In order to install the recommended variable obsolescence rate approach, it will be necessary to obtain a waiver of the specific directives concerning excess computation in DODI 4140.39. The instructions in this area are somewhat contradictory in that the DODI encourages variable obsolescence rate computation without leaving the required latitude to do so.

3. With respect to the last four recommendations, Captains Anselmi, Carlburg, and Clark are available to assist AFLC in implementing and refining the suggested changes. The USAF Procurement Research Office at the Academy has made travel and

per diem funds available for this purpose, and the Academy staff has approved this project as the major summer activity for these officers.

Two final observations are in order. First, feedback from the nineteen cadets involved in Project "EOQ" indicates that the educational benefits derived from this experiment exceeded even the most optimistic expectations. For allowing us to combine research in a critically important Air Force problem with academic training, we owe a debt of gratitude to the senior AFLC managers whose foresight made it possible.

Second, the role of the Air Force Business Research Management Center--and in particular the key role of Major Sanford Kozlen--should be emphasized. The masses of data, the stacks of books and documents, and the valuable contacts could not have been obtained from our remote location without Major Kozlen's energetic and imaginative efforts.

If annual demand (AD) is less than \$300, do not solicit price discounts.

CATEGORY 1: $\$300 \leq AD < \$833$

Solicitation Quantities: EOQ, 3xAD

CATEGORY 2: $\$833 \leq AD < \$2000$

A. If EOQ $\leq$ \$2000

Solicitation Quantities: EOQ, $\frac{EOQ + \$2499}{2}$, \$2499

B. If EOQ $>$ \$2000

Solicitation Quantities: EOQ, \$2499

CATEGORY 3: $\$2000 \leq AD < \$10,000$

A. If EOQ $\leq$ \$2500, Buyer has Three Options

1. OPTION 1: Do Not Solicit Discounts

2. OPTION 2: Remain Within Small Purchase Limit By Soliciting EOQ and Any Quantity Up to \$2499.

3. OPTION 3: Solicit Discounts Using Large Purchase Purchase Procedures as Follows:

FIGURE 5.--Recommended Procedure for Solicitation of Price Discounts[1]

a. If 2xEOQ > 3xAD

Solicitation Quantities: EOQ, 3xAD

b. If 3xEOQ > 3xAD

Solicitation Quantities: EOQ, 2xEOQ

c. If 4xEOQ > 3xAD

Solicitation Quantities: EOQ, 2xEOQ, 3xEOQ

d. Otherwise:

Solicitation Quantities: EOQ, 2xEOQ, 3xEOQ, 4xEOQ

B. If EOQ > $2500

Use Option 3 (Above) to Determine Solicitation Quantities

CATEGORY 4: AD ≥ $10,000

Use Option 3 (Above) to Determine Solicitation Quantities

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[1] Computation of the recommended solicitation quantities will be computerized for the convenience of the buyers.

APPENDIX A

ANALYSIS OF ORDERING COSTS

This appendix deals with an analysis of ordering costs as they are computed by AFLC. Obviously, the accuracy of EOQ computations depends heavily upon the accuracy of the parameters used in the formula. A discussion of the effects of recent changes in the ordering cost parameters is followed by a sensitivity analysis with respect to the effect of future changes on number of buy actions.

COMPUTATION OF ORDERING COSTS

DODI 4140.39 directs that ordering cost factors include the variable-cost portion of direct labor, indirect labor, and other administrative processes connected with the procurement function for each line item of a Purchase Request. A "checklist" with detailed instructions for computing these costs is included as an attachment to the Instruction. As a minimum, computation of separate ordering cost parameters for small purchases (under $2500), large purchases (over $2500), and call-type contracts is directed. AFLC is in compliance with the format for computing the factors and with the minimum requirements for separate computations (although the call-type ordering cost is computed but not used).

A critique by the Project "EOQ" team of the industrial engineering studies used by AFLC in determining the elements of each ordering cost parameter was not possible. First, the team members did not possess the required expertise (work measurement,

time-and-motion, etc.) for such an analysis. Second, even if industrial engineering capability had been available, the opportunity for detailed on-site observation and data collection was not present. Thus, on the question of accuracy of holding cost computations, the team can only observe that AFLC is in compliance with the format and basic stratification of costs directed in DODI 4140.39.

THE EFFECT OF RECENT CHANGES

As discussed in Chapter II, AFLC's EOQ system has been marked by frequent changes in the parameters. Table A-1 indicates the two most recent changes.

TABLE A-1

RECENT CHANGES IN HOLDING AND ORDERING PARAMETERS

EFFECTIVE DATES	HOLDING[a] COST	SMALL-PURCHASE ORDERING COST	LARGE-PURCHASE ORDERING COST
PRIOR TO 1 JUN 73	.39	$127	$379
1 JUN 73-31 MAR 74	.32	$142	$424
1 APR 74-PRESENT	.24	$149	$444

[a]As a decimal fraction of average on-hand inventory

Recalling the basic EOQ formula:

$$EOQ = \sqrt{\frac{2CD}{HP}} \quad ,$$

it is interesting to note that the effect of recent changes in the parameters (Table A-1) is to increase the EOQ quantity. That is, increases in C and accompanying decreases in H have combined to appreciably increase EOQ. Since increases in order quantity have the effect of decreasing the total number of procurement (line item) actions, an analysis of the magnitude of these decreases in buy actions was performed. The results of this analysis are exhibited in Table A-2.

TABLE A-2

EFFECT OF PARAMETER CHANGES ON NUMBER OF BUY ACTIONS (LINE ITEM)

	TOTAL AFLC EOQ BUYS	DECREASE IN NUMBER OF BUYS FROM LAST CHANGE	PERCENTAGE DECREASE IN NUMBER OF BUYS/LAST CHANGE
ORIGINAL (Prior to June 1973)	189,725	--	--
CHANGE #1 (June 1973)	162,420	27,305	14.4%
CHANGE #2 (April 1974)	141,873	20,547	12.6%

Note that, by the simple expedient of twice recalculating the ordering and holding parameters, AFLC has effectively reduced the annual number of buy actions by 25%! Thus, one might conclude that the reduced volume of purchase actions permits experienced, highly trained buyers to do a better job of negotiating on the remaining solicitations.

SENSITIVITY ANALYSIS OF ORDERING COST PARAMETERS

Although the research team did not investigate the accuracy of the ordering cost parameters, a sensitivity analysis of the effect of future changes in these parameters in number of buy actions was accomplished. The results are exhibited in Table A-3.

TABLE A-3

EFFECT OF FUTURE CHANGES IN ORDERING COST PARAMETERS ON TOTAL NUMBER OF BUY ACTIONS

PERCENT CHANGE IN PARAMETERS	-10%	0[a]	+5%	+10%	+50%
TOTAL # BUYS	148,000	142,000	139,000	136,000	118,000
CHANGE	+6,000	--	-3,000	-6,000	-24,000

[a]Present parameters

In summary, the research team feels that AFLC has moved in the right direction in making recent changes to its ordering cost parameters. The reduced number of buy actions, and the

accompanying increase in "quality" made possible by this reduction in volume, represents a major step in improving AFLC's EOQ system.

APPENDIX B

RELAXATION OF BUY CONSTRAINTS

As explained in Chapter II, the baseline model was changed slightly to analyze the effects of relaxing the buy restrictions imposed by DODI 4140.39. The DOD restricts the services from purchasing less than three months worth or more than three years worth of any item. In the sample of 9,767 items, roughly 8% of the items should have been purchased more than four times a year or, in other words, less than three months worth of these items should be bought. The effect of the three-month constraint is to reduce the cost to order (fewer orders per year) and to increase the holding costs. For these items the increase in holding cost exceeded the decrease in ordering cost for a net <u>increase</u> in cost to AFLC. If this restriction were relaxed, the true EOQ would be purchased, decreasing the cost to AFLC.

On the other hand, nearly 12% of the items in the sample were constrained by the three-year buy guideline. The effect of this constraint is to reduce the holding cost but to increase the ordering cost (more buys over the life of the item). For these items the increase in ordering cost exceeded the reduced holding cost--again for a net increase in cost to AFLC. Relaxing this constraint will also allow purchase of the true EOQ for these items and lower total cost.

This model was exactly the same as the baseline model in its ordering cost and obsolescence parameters, but the true EOQ was purchased for each item by relaxing the three-month/three-year

DOD constraints. The annualized results projected for the entire inventory are as follows: acquisition cost remained the same at $348.9 million; holding cost decreased from $23.8 million to $23.3 million; ordering cost decreased from $29.5 million to $26.8 million for a net change in total cost from $402.1 million to $399.0. The number of item buy actions for the sample increased from 14519 to 15699. This change was due to the increase in the number of buy actions for the items affected by the three-month constraint as compared to the decrease in the number of buy actions for the items affected by the three-year constraint.

APPENDIX C

MATHEMATICAL DESCRIPTION OF THE PRICE DISCOUNT SIMULATION MODEL

In order to analyze the effect of price discount solicitation on AFLC's EOQ system, and as a test of the reasonableness of the assumptions made in Chapter III, a price discount simulation model was built, programmed, and run on the Academy's B-6700 computer. The model was applied to the 9,767-item sample (described in Chapter II) by partitioning the sample into seven categories of annual dollar demand. Each category was assigned from two to four standard order quantities (Q_i) to be solicited; the number and magnitude of the Q_i were varied according to the EOQ (Q_o), the small-purchase limit, and the three-month buy constraint. For example: price discounts were disallowed on items having an annual demand less than $200; items whose annual demand exceeded the three-month buy constraint (annual demand greater than $59,200 using current parameters) were assigned solicitation quantities of $\frac{AD}{4}$ (the current "EOQ"), $\frac{AD}{2}$, $\frac{3AD}{4}$, and AD. In no case was the maximum Q_i allowed to exceed the three-year buy restriction.

Based on the assigned Q_i and on a specified distribution of price discounts, solicitation of each of the 9,767 sample items was simulated. P_o, the price per unit for Q_o units, was the most recent price paid for the item and was computed by dividing the standard price from the D062 record by a factor of 1.15. To compute P_1, the simulated price for the next higher quantity Q_i,

a random discount d_1, was generated, so that $P_1 = (1-d_1)\ P_o$. If an additional quantity (Q_2) was involved, then, in order to compute its simulated price P_2, another random discount was generated and applied to P_1; i.e., $P_2 = (1-d_2)\ P_1$. Additional solicitation quantities, if any, were "priced" in a similar manner.

For each item in the sample, total annualized cost (TC) was computed for each of the order quantities and using the simulated unit price.[1] The solicitation was deemed a "failure" if TC_o was less than TC_i, $i > 0$, and was counted as a "success" otherwise. A running total was kept of annual costs (as well as annual acquisition cost) for comparison with the results obtained for the baseline (no price discounts) model.

The rationale for using 3%, 5%, and 8% as "average" discounts in the simulation runs was discussed in Chapter III. The actual distribution used to generate the price discounts is examined below.

THE PRICE DISCOUNT DISTRIBUTION

Very little empirical evidence was available to indicate the

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[1]For the remainder of this discussion, TC_i will denote total annualized cost using an order quantity of Q_i and a unit price of P_i. That is: $TC_i = \frac{CD}{Q_i} + \frac{H\ P_i\ Q_i}{2} + P_iD$.

actual distribution of price discounts. However, since the purpose of the simulation was to make a <u>conservative</u> appraisal of the effect of price discounts, a somewhat novel approach was taken. Several requisite features of the distribution in question are obvious: the minimum value in its domain must be zero (to avoid negative discounts); the maximum value in its domain must be less than 1 (to avoid 100% discounts); and it must be amenable to adjustment of its mean value to any value between 0 and 1. Other desirable features of this theoretical distribution are not so obvious: its maximum domain element might be determinable, based upon an intuitive feeling about "maximum discounts attainable" in the actual case; to assure a conservative assessment of discounts offered, the probability that a randomly drawn discount is less than the mean might be 0.5 or greater; and, as is discussed subsequently, it would be convenient if its cumulative distribution function (cdf) could be solved for its inverse in closed form. Remarkably, a well known probability density function (pdf)--the Beta Function--fills all six of the requirements stated above!

In general, the Beta Function is a two-parameter distribution. For our purposes, the "one-sided" Beta Function was employed. Mathematically, this function and its mean and standard deviation are stated as follows:

$$f(d) = \frac{(B+1)}{a}\left[(1 - \frac{d}{a})\right], \; 0 \leq d \leq a;$$

$$M = \text{mean} = \frac{a}{B+2};$$

$$S = \text{standard deviation} = \frac{a}{B+2}\sqrt{\frac{B+1}{B+3}}\;.$$

Note that there are exactly two independent parameters--a and B--so that, of the three important attributes (mean, standard deviation, and maximum domain element), any two can be set at any desired values. For example, to create a distribution with $M = .03$ and $a = .15$, B is computed to be 3. The resulting standard deviation is: $S \doteq .024$. Another interesting feature of this distribution is that its standard deviation is always less than its mean. Even more important, this pdf has the desired attribute of containing at least 50% of its area (probability) below the mean. Finally, consider the cdf as stated below:

$$F(d) = 1 - (1-\frac{d}{a})^{B+1}, \; 0 \leq d \leq a.$$

Solving the above expression for d (obtaining its inverse) yields:

$$d = a\left\{1 - \left[1-F(d)\right]^{\frac{1}{B+1}}\right\}, \; 0 \leq F(d) \leq 1.$$

A well-known theorem in probability theory states that the cdf of a continuous pdf is itself a random variable whose pdf is the uniform distribution on the interval [0,1]. What this means in the present case is as follows: if a random number R is drawn between 0 and 1 and substituted in the expression:

$$d = a \left\{ 1-[1-R]^{\frac{1}{B+1}} \right\} ,$$

the resulting value of d is a randomly drawn price discount from the original distribution. Since the computer can generate the required random numbers internally, the problem of generating random price discounts from the Beta distribution is solved.

In the actual simulation, nine different combinations of means (3%, 5%, 8%) and maximum discounts (10%, 15%, 20%) were tested. Since it was found that the overall results were minimally affected by the size of the maximum discount, subsequent runs were made with a maximum discount of 15% in order to conserve computer time. An expected, but still remarkable, result was that, in multiple runs using the same average discount, the maximum deviation in total annual cost was less than one half of one percent![2]

PROJECTION OF SIMULATION RESULTS

Since the 9,767-item sample was stratified to include higher percentages of large dollar volume items, direct projection of the simulation results to the entire EOQ system was not possible. Instead, the projection was made based upon the dollar value of

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[2]The Central Limit Theorem strikes again!

each of the seven sample categories as compared to the corresponding dollar value in that category in the overall system.[3] Again, conservative weights were used to avoid overstating the magnitude of total savings.

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[3]The DO62-Z11A report was used for this purpose.

APPENDIX D

OGDEN TEST DESCRIPTION

The Ogden Test was initiated to gain information on the feasibility of soliciting price discounts on EOQ items. Since simplicity was the key factor sought, it was apparent that demands levied on Ogden personnel were to be relatively uncomplicated. It was with this goal in mind that the "Notice to Offeror" form that incorporates solicitation of price discounts was designed (See Figure D-1). The form becomes an addendum to the present standard Form 33, "Solicitation, Offer, and Award." This vehicle provides a method by which a contractor can respond to various requested quantities of a product if he so desires. The form itself is brief and to the point, with the "Notice to Offeror" portion requiring, at most, three computations on the part of the buyer. The "Request For Information" portion of the form was included to determine how closely the solicitation quantities paralleled the manufacturer's economic production quantity.

The price discount form was accompanied by a set of instructions (Figure D-2) for use by the buyer when computing the quantities to be solicited. The following is an explanation of the rationale behind the quantities for which price breaks were solicited and a discussion of the instructions.

1. The first sentence in the instructions is explicit; Ogden personnel simplified this process by having the inventory manager put the EOQ quantity and annual demand quantity on each

NOTICE TO OFFEROR

Solicitation No.________________________

In order to take advantage of price discounts, it may be economical for the government to purchase a quantity larger than that stated in ITEM NO.______________of this solicitation.

If you offer price discounts on this item when purchased in larger quantities, please indicate the per-unit price for one or more of the following quantities.

	QUANTITY IN UNITS	PRICE PER UNIT
(Original Quantity)	_________	$_________
	_________	$_________
	_________	$_________
	_________	$_________

Where budgetary limitations permit, the purchase quantity will be determined using the criterion of lowest annualized total cost to the government. This total cost includes holding and ordering costs as well as the actual cost of the items themselves.

REQUEST FOR INFORMATION

In future solicitations for the purchase of this item, the government may consider order quantities larger than those stated above. Since it is realized that the above quantities may not coincide with what you consider to be economic production quantities, please indicate additional quantity and price information below if you wish to do so.

QUANTITY IN UNITS	PRICE PER UNIT
_________	$_________
_________	$_________

FIGURE D-1.--Test Form for Price Discount Solicitation

INSTRUCTIONS TO BUYER FOR SOLICITATION OF PRICE DISCOUNTS

TO BE USED ONLY FOR EOQ ITEMS

Upon receipt of a PR, obtain EOQ quantity (in units) and AD quantity (annual demand in units) for each line item from the IM.

DO NOT USE THE PRICE DISCOUNT FORM IF:

A. Estimated line item value is less than $2500;

B. PR quantity is substantially greater than AD quantity;

C. PR quantity is substantially less than EOQ quantity.

STEP 1: Place PR quantity on the first line of the form

STEP 2: If PR quantity is approximately equal to $\frac{\text{AD quantity}}{4}$, go to COMPUTATION #1.

STEP 3: If PR quantity is between $\frac{\text{AD quantity}}{4}$ and $\frac{\text{AD quantity}}{2}$, go to COMPUTATION #2. Otherwise, go to COMPUTATION #3.

COMPUTATION #1:

A. Enter 2 x PR quantity on second line of form

B. Enter 3 x PR quantity on third line of form

C. Enter AD quantity on fourth line of form

THE FORM IS COMPLETE--ATTACH TO SOLICITATION

COMPUTATION #2:

A. COMPUTE $\frac{\text{PR quantity} + \text{AD quantity}}{2}$ and enter on second line of the form

B. Enter AD quantity on third line of the form

THE FORM IS COMPLETE--ATTACH TO SOLICITATION

COMPUTATION #3:

A. Enter AD quantity on second line of the form

B. Enter 2 x AD quantity on third line of the form

THE FORM IS COMPLETE--ATTACH TO SOLICITATION

FIGURE D-2.--Instructions to Accompany Test Solicitation Form

test PR.

2. The guidelines in the next portion of the instruction form are presented for specific reasons. Statement A prevents the test from interfering with the normal use of small purchase procedures. Statement B is designed to eliminate any bias introduced by one-time quantitative requirements. Statement C was incorporated in the no-go guidelines because it was felt that quantity requirements substantially below EOQ levels were special in nature and thus, not representive of standard EOQ requirements.

3. The next portion of the instruction sheet contains instructions for computing solicitation quantities. Step 1 is self explanatory, since this amount (PR Quantity) will usually be the EOQ. Step 2 is the first process that requires an actual computation. If a PR quantity meets the requirements of Step 2, it is a high annual cost item for which the EOQ conflicts with the buy guidelines set forth by the DOD; i.e., the EOQ falls under the three month quantity requirement. Under current holding and ordering parameters, these items will have an annual demand over $59,200 and will be purchased every three months. When using Computation 1, the buyer is seeking price discounts on quantities that would normally be purchased at six, nine, and twelve month intervals. Step 3 directs the buyer to go to Computation 2 if the PR quantity falls between the three and six month requirement for the item. Here the concern is with items

that have an annual demand of between $14,800 and $59,200. Use of Computation 2 results in an intermediate solicitation quantity between EOQ and annual demand.

If the PR quantity is over six months demand for an item, Computation 3 is used. Items in this category will have an annual cost of between $5,042 and $14,800.

APPENDIX E

VARIABLE OBSOLESCENCE COMPUTATION

As previously stated, obsolescence is the basic problem in the determination of holding costs. The basic equation given in DODI 4140.39 was used for determining obsolescence, i.e., obsolescence = t/a, where a is the average on-hand and on-order inventories for a given time period, and t is all property sent to disposal in that period.

Initially the holding cost analysis team decided to build the variable obsolescence matrix by using data supplied by the D075 and D062 systems. Each matched pair O_{ij} in the matrix was to be computed by using the potential excess data acquired for each Federal Supply Class (FSC)/Systems Management Code (SMC) from the D075 system and the on-hand and on-order data available for FSC/SMC for the D062 system. (The subscript "i" represents the SMC and the subscript "j" stands for the FSC.) That is,

$$O_{ij} = \frac{(\$\ \text{Potential Excess})ij\ (\text{D075})}{(\$\ \text{On-hand} + \$\ \text{On-order})ij\ (\text{D062})}.$$

Investigation revealed that potential excess as defined in AFLCM 57-6, Chapter 14, Paragraph 14-49, B-20, was not an accurate appraisal of AFLC EOQ item obsolescence. This particular quantity contained items of inventory that, while meeting the criteria for being declared obsolete, were being retained for such reasons as contingency, insurance, and deferred disposal. Further, it was ascertained that in terms of actual obsolescence the D075 data were superfluous to our need. Since the D062 system was found to contain the actual data required, the original approach was discarded, but the algorithm for computing

each O_{ij} was maintained with one change.

Using only the data from the D062 system, a new numerator was calculated. The following equation describes how each obsolescence rate is calculated:

$$O_{ij} = \frac{N_{ij} = \sum n_i}{D_{ij} = \sum d_i}$$

where n_i is the amount declared obsolete or excess to need for a particular budget code (SMC) of a particular stock number. The quantity n_i is determined by computer scan of the information for each item on the D062 EOQ Master and looking for a special code of "D" or "X" in column 89 of each stock number file. (Note: all codes and columns mentioned in this portion of this report can be found in AFLCM 57-6, Chapter Four). If an item is coded D or X, the amount of excess is then multiplied by the unit price (columns 52-60 of the D062 EOQ master tape). When all the n_i are computed, they are summed according to the four-digit Federal Supply Class and arranged by budget code. Thus, $N_{ij} = \sum n_i$ for all j.

Next, we compute d_i, (the amount of inventory on hand) by summing all assets, including items coded C,I,U,O,B,P,X, and D (column 89 of D062 master tape), and multiplying the total by the unit price. These are then summed over Federal Supply Class according to budget code (SMC).

Therefore, the general computation is easily derived from

data available on the DO62 system. Required data elements are limited to special coded items, serviceable assets (less intransit assets and depot supply), due-in assets, unit price, System Management Codes (budget codes), and Federal Supply Class. With this information, each historical O_{ij} can be computed, i.e.,

$$O_{ij} = \frac{\sum [(\text{D or X assets}) \cdot (\text{unit price})]_i}{\sum [(\text{serviceable assets + due in assets, including special coded items}) \cdot (\text{unit price})]_i}$$

with the summation occurring over each four-digit Federal Supply Class. When O_{ij} is derived, it is entered into its proper place in the FSC/SMC matrix (Figure 1-E). Since unserviceable assets have been used once and thus are accounted for, they are <u>not</u> netted into the available asset.

VARIABLE OBSOLESCENCE RATE MATRIX

The Variable Obsolescence Rate Matrix was built in order to store data on historical obsolescence rates. The purpose of the matrix is to supply the actual obsolescence rate of an item rather than the average obsolescence rate currently being used for all Economic Order Quantity computations. As a result of using the standard 13% obsolescence factor, most EOQ's are now being either overstated or understated.

The matrix is based on three variables--Federal Supply Class, System Management Code, and obsolescence rate. The Federal Supply Class (FSC) identifies the particular class of

stock item. The System Management Code (SMC) identifies a specific weapons system. The obsolescence rate is computed for each FSC item. Each item corresponds to a particular SMC except for items classified as 9999, which represents multi-purpose items. The end result of the computation is a breakdown of FSC's by SMC. An obsolescence rate is associated with each SMC/FSC pair. This number represents the summed obsolescence rates of all items within a particular FSC that are used on a specific weapons system (See Figure 1-E).

For example, Federal Supply Class 1270 designates Aircraft Gunnery Fire Control Components. Under this FSC, one of the SMC's is 102Z, the B-58 (all series). The obsolescence rate for all FSC 1270 items that are used on the B-58 is 100 percent.

SMC / FSC	100Z	101Z	102Z	107Z	119Z	122Z	129A	133Z	140A
1005		.0011							
1010									
1095									
1270	1.000	.0008	1.00						
1280		.0077							
1338									
1377									
1420									
1430									
1440						.0046			
1450				.1041		.0026			
1560					.0005				
1610									
1615									
1620									
1630									
1650									
1660									
1670									
1680									
1710									
1730		.0022	.9292						
1740									
2420									
2510									
2520									
2530									
2540									
2590									
2620									
2805									
2820									
ETC.									

There are 341 System Management Codes and 311 Federal Supply Class on the current EOQ master tapes. Of the possible 106,041 SMC/FSC pairs many do not exist because of impossible combinations. Using current D062 data, technological or quantity obsolescence was found to exist for 634 SMC/FSC pairs. Computed obsolescence varied from minute percentages to very high percentages. Less than .006% of the possible matrix combinations had obsolescence rates and for the most part they fell in the 1-2% range.

FIGURE E-1.--Variable Obsolescence Matrix

APPENDIX F

FORECASTING TECHNIQUES

The purpose of this appendix is to describe the forecasting techniques tested, the method of testing, and the results of the test. Five different techniques were tested: eight period moving average; single, double and triple exponential smoothing; and simple linear regression. A special multiple regression approach to forecasting demand for certain aircraft-related spares is also discussed.

THE FORECASTING TECHNIQUES

The eight period moving average is the forecasting technique presently used to predict future demand. The technique may be expressed as:

$$D = \frac{1}{8} \sum_{t=1}^{8} d_t$$

where: D = forecasted demand per period (quarter)

d_t = demand in past period t, where t=1 represents oldest demand.

This technique assigns equal importance or weight to each of the eight periods of demand.

Single exponential smoothing differs from a moving average in that, as the historical demands become older, they receive decreasing weight. Single exponential smoothing may be expressed as:

$$D_t = \alpha d_{t-1} + (1-\alpha) D_{t-1} ;$$

D_t = forecasted demand

d_{t-1} = demand in current period

D_{t-1} = forecasted demand in the period t-1

α = a smoothing constant.

The smoothing constant determines the weight assigned to the most recent demand. According to Brown,[1] this constant rarely needs to be greater than .3. If a higher constant seems desirable, then some other prediction technique should probably be used. In this study, three different smoothing constants were tested: .1, .2, and .3.

Double exponential smoothing incorporates a correction for a linear trend. This technique is somewhat more complicated than single exponential smoothing, but if the following steps are followed, a forecast can be obtained:

Step 1: Perform single exponential smoothing operation.

$$D1_t = \alpha d_{t-1} + (1-\alpha)D1_{t-1}$$

Step 2: Smooth the results of the single smoothing.

$$D2_t = \alpha D1_t + (1-\alpha)D2_{t-1}$$

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[1]Brown, Robert G., Smoothing, Forecasting and Prediction of Discrete Time Series, Englewood Cliffs, N. J.: Prentice Hall, Inc., 1963.

Step 3: Compute the constant term.

$$a_t = 2\ D1_t - D2_t$$

Step 4: Compute the slope or variable coefficient.

$$b_t = \frac{\alpha}{1-\alpha}\ (D1_t - D2_t)$$

Step 5: Solve this equation for the forecast.

$$D_{t+\tau} = A_t + b_t \cdot \tau$$

The symbol τ stands for the period in the future for which the forecast is being made. For example, if the forecast is for the fourth quarter into the future, then $\tau = 4$. As in single exponential smoothing, three different values of the smoothing constant were used: .051, .106, and .163. These are the equivalent values of those used in single exponential smoothing as defined by Brown.

Triple exponential smoothing incorporates a correction for a constantly increasing or decreasing trend. Forecasting using this technique is a rather involved process, but it too can be broken down into a number of simple steps as follows:

Step 1: Perform single exponential smoothing operation.

$$D1_t = \alpha d_{t-1} + (1-\alpha)\ D1_{t-1}$$

Step 2: Smooth the results of the single smoothing.

$$D2_t = \alpha D1_t + (1-\alpha)\ D2_{t-1}$$

Step 3: Smooth the results of the double smoothing.

$$D3_t = \alpha D2_t + (1-\alpha)\ D3_{t-1}$$

Step 4: Compute the constant term:

$$a_t = 3\,D1_t - 3\,D2_t + D3_t$$

Step 5: Compute the linear coefficient:

$$b_t = \frac{\alpha}{2(1-\alpha)}\left[(6-5\alpha)D1_t - 2(5-4\alpha)D2_t + (4-3\alpha)D3_t\right]$$

Step 6: Compute the rate of change coefficient.

$$c_t = \frac{\alpha^2}{(1-\alpha)^2}\left[D1_t - 2\,D2_t + D3_t\right]$$

Step 7: Solve this equation for the forecast:

$$D_{t+\tau} = a_t + b_t \cdot \tau + \frac{1}{2} c_t \cdot \tau^2$$

Again, three equivalent values for the smoothing constant were tested: .035, .072, and .112.

The final forecasting technique tested was simple linear regression. For an eight period regression the following expressions will give the desired forecast.

$$b = \frac{8 \sum_{t=1}^{8} t\, d_t - 36 \sum_{t=1}^{8} d_t}{336}$$

$$a = \frac{\sum_{t=1}^{8} d_t}{8} - 4.5b$$

$$D_t = a + bt$$

where: d_t = demand in period t

a = constant

b = coefficient of variable

D_t = forecasted demand in time period t, where $t > 8$.

Linear regression is similar to double exponential smoothing in that both recognize linear trends. An important difference is that linear regression weights all data the same, whereas double exponential smoothing places more weight on recent data.

THE TESTING METHOD

The eleven demand prediction techniques were tested, using a data base of four years of actual AFLC EOQ demand history. The first eight quarters of demand history were used to simulate a forecast for each of the eleven prediction techniques. These forecasts were compared to the demand actually experienced in the next two years. The difference between the actual demand and the forecast is called a forecast error. Four criteria were used to select the best predictor: (1) smallest Mean Absolute Deviation (MAD), the absolute sum of the forecast errors for the eight periods forecast; (2) smallest weighted MAD, in which a heavier weight is placed on forecasts closer in time than more distant forecasts; (3) smallest Sum of the Squared Deviations (SSD), the sum of the squared forecast errors for the eight periods forecast; (4) smallest weighted SSD.

A sample of 7014 items was used to test the predictors. An edit eliminated 905 items as having not enough demand activity to be predictable. An eight quarter forecast was made for each item, using each prediction method. Count was kept of the number of times each predictor gave the "best" prediction, using each of the

four criteria. The results of this simulation are contained in Table F-1. From the table, it can be seen that single exponential smoothing with smoothing constant of .1 is the best overall predictor

REGRESSION PROJECT FOR AIRCRAFT RELATED ITEMS

When Project "EOQ" was begun, one area that was chosen for study was demand prediction. The object of the study was to determine better methods for accurately predicting demand. Although there are many different demand prediction techniques, it was felt that the demand for certain high dollar items could be associated with system-related variables. This particular portion of the demand study deals with these items and the factors which affect their demand.

Most of the top 250 high dollar demand items in the Air Force inventory are aircraft-related items. For the purposes of this study, only those aircraft parts which are related to one specific type of aircraft were selected for analysis. For example, the brake disc rotor of the F-4, which has an annual dollar demand of $1,164,096, is one such item. This item is used on only the F-4 and is not interchangeable with any other aircraft. By using items related to only one aircraft, the number of factors which affect demand can be narrowed to a manageable number.

With aircraft related items, there are certain factors which

TABLE F-1

RESULTS OF PREDICTION METHOD TEST

PREDICTION METHOD	CRITERIA MAD	WMAD	SSD	WSSD	TOTAL
Moving Average	628	523	714	771	2636
Single Exponential Smoothing					
WT = .1	2313	2200	1634	1538	7685
WT = .2	363	390	469	489	1711
WT = .3	460	621	655	669	2405
Double Exponential Smoothing					
WT = .051	230	227	229	231	917
WT = .106	207	202	232	223	864
WT = .163	159	168	239	245	811
Triple Exponential Smoothing					
WT = .035	350	385	306	338	1379
WT = .072	240	227	292	268	1027
WT = .112	508	485	673	685	2351
Linear Regression	651	681	666	652	2650
Total	6109	6109	6109	6109	24436

would logically affect item demand, one of which is aircraft flying hours. Aircraft flying hours is a data set which is easy to obtain and which is accurately recorded. Further analysis, however, showed that other factors were readily available which were also logical drivers of demand. Two of these factors which were included in the study are aircraft inventory and aircraft sorties. By including these factors, we are able to more accurately predict demand for all parts. For instance, the rate at which the brake disc rotor of the F-4 wears out is not dependent so much on the number of flying hours, but on how many times the plane lands. An accurate representation of landings is the number of sorties.

The demand technique used to compare how flying hours, inventory, and sorties affected demand for aircraft parts is regression analysis. Regression analysis attempts to establish the nature of the relationship between variables. That is, in linear regression analysis we study the functional relationship between the variables so that we may be able to predict the value of one variable (aircraft parts demanded) on the basis of others (flying hours, inventory, sorties). In this case, the independent variables are flying hours, inventory, and sorties; the dependent variable is aircraft parts demanded. The measure of how well the regression analysis explains aircraft parts demanded is called the correlation coefficient. The correlation coefficient reveals how

much of the variation in aircraft parts demanded is explained by the independent variables. A perfect predictor will have a coefficient of 1; a less accurate predictor will vary between 1 to 0.

By comparing the prediction model against previous demand, the accuracy of the prediction scheme can be assessed. The last eighteen quarters of demand data for each item were available--as were the last seven years of flying hours, sorties, and inventory for all USAF aircraft. Although fifteen aircraft-related items were randomly chosen for study, three of these items had to be eliminated because of extremely low demand trends.

The first regression analysis was a regression of quarterly demand against the corresponding quarterly values of flying hours, inventory, and sorties. Regressing flying hours against aircraft parts demanded was the poorest predictor of all. Correlation coefficients ranged from .04 to .41, with an average correlation of .253. Sorties was the next best individual predictor with a range from .04 to .50 and an average correlation of .284. The best individual predictor was inventory; correlation coefficients ranged from .02 to .68 with an average correlation of .336. Of the twelve items, inventory was the best predictor six times, sorties three times, and flying hours three times. When all three variables were regressed against items demanded, the correlation coefficients ranged from .13 to .75

with an average correlation of .474, showing that individually, the variables are poor predictors. However, taken together, the variables explain much more of the variation in demand.

The second regression analysis was performed with a one quarter time lag in items demanded. The theory was that there could be delays from the time the aircraft part was actually needed until the aircraft part was actually received or re-stocked. In this analysis, sorties were the poorest individual predictor with correlations ranging from .00 to .43, and an average correlation of .209. The next best predictor was flying hours with a range of .02 to .59 and an average correlation of .219. Again, the best individual predictor was inventory, with a range of .01 to .62 and an average correlation of .386. Out of the twelve items, inventory was the best predictor eight times and flying hours four times. When all three variables were regressed against items demanded, the correlation range was .26 to .71, with an average correlation of .524. These figures indicated that the inclusion of two or more variables obtains better results.

In comparing the straight regression against the one quarter delay, it was found that there are significant improvements in some (but not all) areas. The one quarter delay regression of flying hours versus parts demanded decreased the correlation coefficient in six of the twelve items, resulting in an average

correlation drop of .034. The one quarter delay regression again showed poorer results in the sorties vs. parts demanded when it decreased correlation coefficients in six of the twelve items, resulting in an average correlation drop of .084. Two regressions, however, showed improvement with the one quarter delay. Inventory vs. parts demanded showed an increase in eight of the twelve items, with an average correlation increase of .05. Regression of all three variables against parts demanded showed an increase in seven of the twelve items, with an average correlation increase of .05.

The results of this study are inconclusive, but the study does point out some viable alternatives which could possibly lead to significant improvements. The first recommended alternative would be the addition of more independent variables. These could possibly include maintenance hours performed on the aircraft, number of major overhauls or checkups, or number of pilots available. These are only suggestions, however, and the problem is the availability of the required data. The second alternative is more feasible--and more within the scope of this analysis. Although the one quarter delay did not show improvements in all areas, there was improvement in some. By putting a one quarter time lag on inventory but not on sorties and flying hours and then regressing all three against parts demanded, significantly better results might be obtained.

Although a specific recommendation cannot be made as a result of this study, correlations as high as .75 show that this area deserves further study. Therefore, it is recommended that this study be continued with a broader data base and more thorough analysis.

SUMMARY OF CORRELATIONS

	STRAIGHT REGRESSION/					/ONE QUARTER DELAY				
STOCK NUMBERS	INVENTORY	SORTIES	FLY HR	INV, SORT, FH	BEST INDIVIDUAL PREDICTOR	INVENTORY	SORTIE	FLY HR	INV, SORT, FH	BEST INDIVIDUAL PREDICTOR
1630 2262374	.40	.48	.25	.59	Sortie	.51	.43	.03	.71	Inv
BF 1560 9547751	.49	.28	.30	.54	Inv	.52	.34	.38	.60	Inv
BJ 6615 9466069	.06	.18	.15	.49	Sortie	.19	.09	.09	.31	Inv
BF 1560 0770858	.51	.43	.41	.63	Inv	.58	.16	.41	.63	Inv
BF 1560 0770859	.34	.50	.40	.58	Sortie	.47	.37	.59	.69	FH
BF 1560 4375445	.12	.12	.16	.18	FH	.45	.15	.14	.52	Inv
BF 1560 8302721	.60	.46	.16	.75	Inv	.62	.23	.10	.66	Inv
BF 1560 9018208	.58	.04	.20	.58	Inv	.49	.08	.02	.52	Inv
BF 1560 9018209	.68	.20	.26	.68	Inv	.55	.24	.07	.61	Inv
BF 1560 9369272	.13	.04	.04	.13	Inv	.20	.11	.21	.36	FH
BF 1650 7866997	.11	.13	.14	.22	FH	.05	.00	.20	.26	FH
BF 1650 7870919	.02	.15	.15	.32	FH	.01	.31	.39	.42	FH
AVERAGE CORRELATION	.336	.284	.253	.474		.386	.209	.219	.524	

APPENDIX G

SAFETY LEVEL ANALYSIS

Safety level policy requires the balancing of two opposing costs: the cost of holding seldom-used stock versus the cost of not filling a customer's order. (To date, there is no accepted method of measuring stockout cost in the Air Force. In its place, we use fill rate--number of orders filled versus number of orders received). Safety level policy should be directed toward minimizing the sum of these two costs. Since we are unable to "cost" stockouts, our goal can be redefined as achieving a fixed fill-rate at the least cost or--what amounts to the same thing--the highest fill-rate at a fixed cost.

The current AFLC policy involves the use of one month's demand as a safety level for all EOQ items regardless of price. A comparison of this policy with one using a variable safety level indicates that fill-rate can be increased while decreasing investment in safety-level stock. This appendix will discuss how a variable safety level might be computed and the benefits to be realized from its use in the D062 system.

SAFETY LEVEL COMPUTATION

The critical element of information needed to compute safety levels is some measure of the variability of demand during procurement lead time (PLT). If demand never varies, there is no need for safety levels (assuming that procurement lead time also never varies). There are many measures of variability, but the method used in this study was the standard deviation of forecast

errors during PLT. Two different techniques were used to compute the standard deviation, depending on nature of the item's demand histories.

If an item's demand history placed it in category 3 (coefficient of variation less than one and at least three quarters of positive demand in the last eight quarters) then the standard deviation of forecast errors was computed from the Mean Absolute Deviation (MAD) by dividing by .79788.[1] This standard deviation was then adjusted upwards, depending on the length of the PLT to give the standard deviation during PLT (as suggested by Brown).

If the item fell into category 2 (normalized standard deviation greater than one and at least three quarters of positive demand in the last eight quarters) computation of the standard deviation of forecast errors during PLT was somewhat more complicated. Again, Brown suggests a computational method. The method is best explained through the use of an example. Suppose an item had eight quarters of demand history as follows: 1,0,0,2,0, 0,3,0. Suppose also that it had a PLT of three quarters. Therefore, in order to determine its standard deviation during PLT, the following computation is done:

Step 1: Divide demands into successive groups of PLT length.

Example: 1,2,2,2,3,3

Step 2: Compute the mean demand during PLT.

Example: (1+2+2+2+3+3)/6 = 2.166

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[1]Brown, Robert G., Smoothing, Forecasting and Prediction of Discrete Time Series, Englewood Cliffs, N. J.: Prentice Hall, Inc., 1963.

Step 3: Compute the mean squared demand during PLT.

Example: $(1+4+4+4+9+9)/6 = 5.17$

Step 4: Square the mean demand during PLT and subtract it from the mean squared demand during PLT and take the square root of the answer. The result is the standard deviation during PLT.

Example: Standard Deviation = $\sqrt{5.17-4.71} = .67$

The standard deviation of forecast errors during PLT is a very useful bit of information which indicates how large a safety level is necessary to assure a certain fill-rate. For example, if a fill-rate of 84% were desired, then one would use a safety level of one standard deviation for all items. If a fill-rate of 98% were the target, then one would set all safety levels at two standard deviations. However, either of these policies would be less than optimal since either fill-rate could be had for less dollar investment in safety level. Therefore, the next step was to vary the size of the safety level, depending on the cost of the item. The cheaper the item, the higher the safety level that can be set. For very inexpensive items, a safety level large enough to insure against stockouts 99% of the time would be desirable; on expensive items, perhaps no safety level at all should be maintained. Using the above philosophy, eight different categories of safety level protection were established.

COMPARISON OF PRESENT AND PROPOSED METHODS

A computer program was developed to compare the results of

using the present method of determining safety level with the method using a variable safety level. The results were dramatic. In a 7000 item sample, the fill rate could be increased by 4.4% while reducing the investment in safety level by 15%.

EPILOGUE

Subsequent to the formal briefing on 22 May 1974 at the USAF Academy, the officers on the project briefed the AFLC Deputy Chiefs of Staff for Materiel Management, Comptroller and Procurement at Wright-Patterson AFB on 20 June 1974. As a result of this briefing and after extensive working sessions with Headquarters AFLC staff members, the following modified implementation plan was developed.

Price Discounts

It was decided to expand the Ogden test to include all EOQ buys at Ogden above $2,500. A joint USAFA/AFLC team developed the necessary procedures to implement this decision at Ogden ALC during the week of 8-12 July 1974. From July through October 1974, this test will be closely monitored by Headquarters AFLC. Based on the results of this test, a decision will be made in October or November to implement the price discount procedures at the other four ALCs. Expansion of the price discount procedures to buys under $2,500 will be delayed until the procedures can be largely mechanized, probably sometime in 1975.

Variable Obsolescence

Although the AFLC staff agreed with the concept of variable obsolescence, they did not agree with the way in which the team computed it. The team believes that the obsolescence rate

should be based only on items that are disposed of because they are, in fact, obsolete. Both DOD and AFLC believe that the rate calculation should also include those items that are disposed of because they are excess to the government's requirement. Therefore, a new rate that includes disposal of excess in its calculation is being developed by the Academy, and will be tested by AFLC in August. If the results of the test are positive, AFLC will implement the use of a variable obsolescence rate as soon as the necessary data system changes can be made.

Demand Prediction

In the near future, AFLC will change the way it predicts demand for EOQ items and the way safety levels are determined. The Academy's methods of demand prediction and safety level determination were not tested against these new AFLC methods, but against the methods presently used by AFLC. Therefore, it was decided to do a side-by-side simulation of the Academy's methods with the new AFLC methods. The Academy is doing the simulation, using criteria approved by AFLC. The results of the simulation will be presented to AFLC in August 1974, and a decision will be made at that time to incorporate none, some, or all of the Academy's methods.